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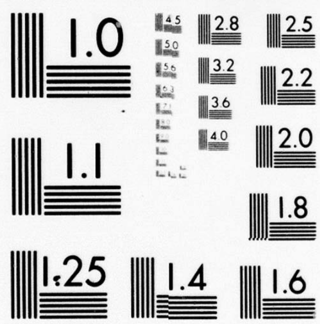

MICROCOPY RESOLUTION TEST CHART

Report No. FAA-RD-79-71

INTERIM RESULTS OF DABS/ATCRBS ELECTROMAGNETIC COMPATIBILITY TESTING

George Mahnken

Leo Wapelhorst

INTERIM REPORT

JUNE 1979

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16. Abstract

This report describes the tests being conducted at the National Aviation Facilities Experimental Center (NAFEC) to determine what effect the implementation of the Discrete Address Beacon System (DABS) will have on the performance of the Air Traffic Control Radar Beacon System (ATCRBS), and presents interim results on the tests conducted to date. Uplink tests were conducted to measure transponder suppression rates in the ATCRBS airborne environment under various DABS and ATCRBS ground interrogator site configurations. Analysis of the data collected to date indicates that suppression levels generally become lower when DABS sensors replace ATCRBS sites, thus, resulting in an improvement in the ATCRBS airborne environment. Tests were also conducted on three reply processors being used by the Federal Aviation Administration (FAA) in operational facilities to process ATRCBS targets to determine processor susceptibility to DABS fruit interference. There was no indication from the resultant data of any significant degradation in performance in the presence of varying amounts of DABS fruit.

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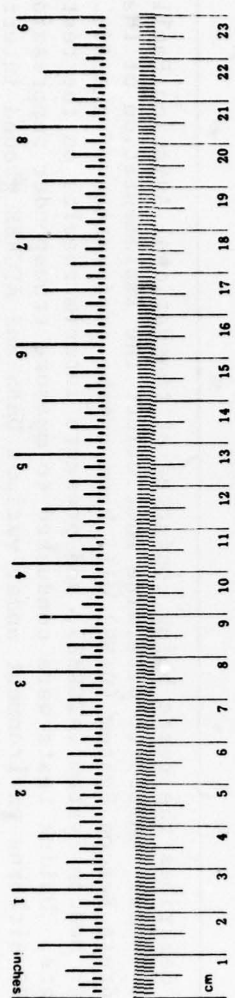
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

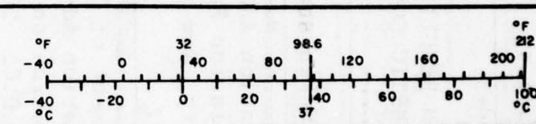
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

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INTRODUCTION

PURPOSE OF REPORT.

The purpose of this report is to present interim results on the uplink and reply processor electromagnetic compatibility tests conducted to date at National Aviation Facilities Experimental Center (NAFEC). As part of the uplink test effort several flights were made to measure transponder suppression rates under various ground interrogator site configurations. Similarly, several Air Traffic Control Radar Beacon System (ATCRBS) reply processors have been tested to determine their susceptibility to Discrete Address Beacon System (DABS) fruit. Neither the uplink suppression tests nor the reply processor tests have been completed, but sufficient testing has been accomplished to warrant publication of the interim test results contained herein.

BACKGROUND.

The DABS is being developed by the Federal Aviation Administration (FAA) as an evolutionary upgrading of the existing ATCRBS. DABS provides improved surveillance data and an integral ground-air-ground digital communications data link to support advanced air traffic control automation. DABS has been designed to be compatible with ATCRBS to permit an orderly and economical transition from an all-ATCRBS environment to an all-DABS environment. The DABS design achieves this compatibility by using signal waveforms that operate on the same frequency channels as ATCRBS and supports ATCRBS functions as well as the new DABS functions.

PURPOSE OF TEST ACTIVITY.

The common channel usage by DABS and ATCRBS raises the issue of mutual interference. The question to be answered is would the implementation of DABS degrade the performance of neighboring unmodified (non-DABS) ATCRBS installations during the ATCRBS-to-DABS transition period. A theoretical DABS/ATCRBS interference analysis conducted by Lincoln Laboratory ("Discrete Address Beacon System (DABS) Air Traffic Control Radar Beacon System (ATCRBS) Interference Analysis," Report No. FAA-RD-78-147) hereafter referred to as the theoretical analysis was performed and concludes that DABS can coexist with ATCRBS on the same frequency channels on a non-interfering basis. The purpose of this test effort was to verify the predictions and conclusions resulting from the theoretical analysis.

TEST OBJECTIVE.

The objective of the DABS/ATCRBS electromagnetic compatibility test activity was to quantitatively determine the effect of DABS transmissions on ATCRBS performance on the interrogation (uplink) and reply (downlink) channels, and to determine corrective action if a compatibility problem should be found to exist.

TECHNICAL APPROACH.

Test configurations were established to examine in detail the potential interference mechanisms identified in the theoretical analysis. The test configurations included live flight tests for verification of the uplink channel predictions and the use of appropriate environment drivers which provided realistic representations of the operating environment at the input port of operational ATCRBS processors.

RELATED ACTIVITIES.

DABS/ATCRBS electromagnetic compatibility computer simulations are being conducted by the Electromagnetic Compatibility Analysis Center (ECAC) for the FAA. The NAFEC test data resulting from live flight tests and tests conducted with the actual operational reply processors will be used to crosscheck the results obtained from the ECAC computer simulations.

A joint FAA/DOD program is beng established to investigate the compatibility of DABS with the military Mode 4 operation. Test results will be the subject of a separate report.

SCOPE OF EFFORT.

The equipments tested were current operational equipments in the FAA inventory and ATCRBS equipments used jointly by the FAA and the Department of Defense (DOD) for air traffic control operating on 1030 megahertz (MHz) and 1090 MHz frequencies.

DABS OPERATION

DESCRIPTION OF OPERATION.

DABS is a cooperative surveillance and communication system for air traffic control. Each aircraft is assigned a discrete address or unique code which permits data link communications to or from a particular aircraft. The data link operates integrally with DABS surveillance interrogations and replies. DABS has two modes of operation; ATCRBS mode and the DABS mode. DABS uses the channel first for ATCRBS functions and then uses the channel to perform DABS functions. This is possible because DABS employs monopulse direction finding which permits reliable and improved ATCRBS surveillance data to be obtained with a nominal 4 "hits" per target contrasted to today's ATCRBS which nominally tries to obtain 16-30 "hits" per target. The time between ATCRBS interrogations is used by DABS to perform DABS surveillance and data link communications. In the DABS mode, surveillance data on a DABS-equipped aircraft can be obtained normally with a single interrogation (the reinterrogation factor is about 10 percent). Because of the discrete address, DABS can schedule its interrogations such that responses to its discrete interrogations are never received simultaneously. Only aircraft on the sensor's "roll-call" list can be discretely interrogated. To acquire targets not yet on the sensor's "roll-call" list,

DABS transmits, when in the ATCRBS mode, an ATCRBS/DABS All-Call interrogation which is similar to todays corresponding ATCRBS interrogatin with an additional pulse-P4. An ATCRBS transponder is unaffected by the presence of the P4 pulse and responds with a normal ATCRBS reply. DABS transponders recognize the interrogation as a DABS all-call interrogation and responds with a DABS all-call reply which contains its discrete address.

After determining its position, the sensor places the target on its "roll-call" list. On a subsequent discrete interrogation the DABS transponder can be locked-out from replying to all-call interrogations therby eliminating unwanted replies. In the ATCRBS mode, DABS transmits a P_2 suppression pulse on the omni-directional antenna each time there is an ATCRBS/all-call interrogation just as is presently done in the current ATCRBS today to suppress ATCRBS transponders outside of the antenna's main beam. In the DABS mode, each discrete interrogation consists of a preamble which consists of P1-P2 suppression pulse pairs to suppress ATCRBS transponders that are in the antenna mainbeam with the particular DABS target being interrogated. This intentional suppression (nominally 35 μs) is to prevent unwanted ATCRBS replies from being triggered by a discrete interrogation.

Each DABS reply consists of a four pulse preamble which is designed to make the DABS reply easily distinguishable from an ATCRBS reply. DABS replies can be 64 μs or 120 μs long as compared with an ATCRBS reply which is nominally 20.3 μs.

POTENTIAL INTERFERENCE MECHANISMS.

It was found in early DABS studies that any form of data modulation could trigger many ATCRBS transponders to respond with unwanted replies. DABS prevents this by using an interrogation waveform which will intentionally suppress any ATCRBS transponder which detects the interrogation. The remainder of the DABS transmission is then completed during the nominal 35 sec ATCRBS suppression interval. Therefore, the potential uplink interference mechanism is the intentional suppression of ATCRBS transponders. DABS has the capability of transmitting extended length messages (ELM) which may contain up to 16 segments. The ELM segments or Comm-C interrogations can be transmitted in a burst with a minimum spacing of 50 μs. The transmission of multiple segment ELMs raises questions regarding the effect that these interrogations have on the ATCRBS transponders' round reliability especially when the ATCRBS is in the main beam with more than one DABS target receiving multisegment ELMs. Nominally, the peak interrogation rate of DABS is 198 interrogations in 125 milliseconds (ms). If the sensor is working in a network and an adjacent site fails the peak interrogation rate could increase to 350 interrogations per 125 ms.

DABS asynchronous replies or fruit is the principal interference mechanism on the downlink channel. A DABS reply is either 64 μs or 120 μs long and is transmitted using pulse position modulation. The DABS reply has pulse widths and spacings which are close to those used in ATCRBS replies. Thus, a DABS reply may be falsely decoded as a string of overlapping ATCRBS reply brackets.

ATCRBS reply processor performance may be degraded due to the false bracket decodes. Additionally, ATCRBS replies that are garbled by DABS fruit may be destroyed and thus go undetected or erroneously decoded. This also may degrade reply processor performance.

UPLINK SUPPRESSION TESTS

TEST APPROACH.

Several flight tests have been conducted to date to measure the ATCRBS airborne environment. Using the Flight Inspection Monitor (FIM) equipment described in appendix A, suppression and interrogation levels were counted, recorded and analyzed for several different ATCRBS and DABS site configurations. The results as discussed later in this report, were than compared with the theoretical analyses referred to earlier.

AIRCRAFT CONFIGURATION.

Normally flight tests that are conducted using FIM are made in a Convair 580 with the FIM receiving antennas configured as shown in figure A-2. The first series of test runs were made on May 7, 1979, and used this configuration. A second series of test runs conducted on June 12, 1979, to verify the May 7 tests were made using a Grumman (G-1) Gulfstream. A single AT-741 antenna located at station 470, about three-fifths of the way back on the bottom center line was used in a single receiver hookup to the FIM equipment.

GROUND INTERROGATOR ENVIRONMENT.

The ground interrogator sites that are a part of the NAFEC complex were monitored during the flight test period. Each of the sites, along with their operating parameters are outlined below.

A. The Terminal Facility for Automation and Surveillance Testing (TFAST)

1. Antenna: Prototype 4-foot open array
2. Rotation Rate: 12.7 revolutions per minute (rpm)
3. PRF: 343 interrogations per second (ips)
4. Peak Power: 160 watts
5. Normal Operation: Side Lobe Suppression (SLS) only

B. The Enroute Facility for Automation and Surveillance Testing (EFAST) located at Elwood, New Jersey

1. ATCRBS Antenna: ARSR-2/NADIF
2. Rotation Rate: 6 rpm
3. PRF: 360 ips
4. Peak Power: 400 watts
5. Normal Operation: SLS only.

C. The Terminal Radar Beacon Test Facility (TRBTF)

1. Antenna: FA-8043 28 foot "Hog Trough"
2. Rotation Rate: 15 rpm
3. PRF: 310 ips
4. Peak Power: 200 watts
5. Normal Operation: Improved Side Lobe Suppression (ISLS)

D. DABS (Collocated with the TRBTF but radiating from a different tower)

1. Antenna: 5-foot open array
2. Rotation Rate: 12.7 rpm
3. PRF: variable
4. Peak Power: 100 watts

E. The Eastern Region's commissioned facility (commonly called the ASR-4 site)

1. Antenna: FA-7202 28 foot "Hog Trough"
2. Rotation Rate: 15 rpm
3. PRF: 380 ips
4. Peak Power: 160 watts
5. Normal Operation: ISLS

F. Other ATCRBS ground interrogator facilities near NAFEC which had some affect on data collected include:

1. Philadelphia International Airport (41 nmi, NW)
2. McGuire Air Force Base (34 nmi, N)
3. Dover Air Force Base (46 nmi, SW)
4. Gibbsboro long range radar site (28 nmi, NW)

FLIGHT TEST PROFILE.

In all of the flights, the test aircraft followed the flight profile shown in figure 1. At an altitude of 4,500 feet and northeast of NAFEC, a heading of 195 degrees was established prior to passing over the DABS/TRBTF site and proceeding outbound. Upon reaching a point 30 nautical miles (nmi) from NAFEC the aircraft reversed course and proceeded inbound to pass over the site again.

TEST CONDITIONS.

To simulate the actual implementation and transition to DABS; i.e., direct replacement of the existing ATCRBS ground stations with DABS, two basic test operating conditions were established and flight tested with the NAFEC facilities.

The first, identified as the "ATCRBS" configuration was to baseline the existing ATCRBS suppression environment and consisted of normal interrogations from the ASR-4 (ISLS), the TRBTF (ISLS), and the TFAST (SLS) sites located at NAFEC.

The second, identified as the DABS "XXX" configuration was to simulate the transition of DABS into the ATCRBS environment and consisted of three separate subset configurations differing only by the interrogation rates used. The three subsets are described as follows:

SUBSET A. DABS "500". This test condition used a DABS interrogation rate of 500 roll-call interrogations per second. It was selected because the particular hardware needed already existed for another purpose; namely, to align and calibrate the sensor. More importantly, this interrogation rate exceeded the 365 average interrogation rate shown in table 4, page 60 of the theoretic analysis required for DABS to accommodate the traffic density of the FAA Los Angles 1982 design model.

SUBSET B. DABS "1000". This test condition used a DABS interrogation rate of 1000 roll-call interrogations per second. Similarly, it was picked for hardware convenience to exceed the average interrogation rate of 799 interrogations per second required for the 1995 FAA design model also shown in table 4 of the theoretical analysis.

SUBSET C. DABS "LA BASIN". This configuration was developed originally to test the DABS engineering model capacity. The scenario is based upon the 1982 traffic model but with most of the aircraft located in a 90 degree sector. It consist of 180 ATCRBS and 220 DABS equipped aircraft. The ATCRBS aircraft were interrogated at a rate to provide four ATCRBS "hits" per beam dwell. Each DABS aircraft was interrogated up to three times for surveillance, Comm-A or Comm-B message delivery.

The EFAST at Elwood and other facilities at NAFEC (ramp testers, etc) were turned off for the tests. The facilities previously mentioned as being near NAFEC could not be controlled and were assumed to be interrogating in a standard configuration for that facility as governed by their individual operational procedures.

A summary of the ground interogator environment for each test run is shown in table 1.

TABLE 1. SUMMARY OF UPLINK TEST CONDITIONS

RUN NO.	TRBTF	DABS
May 7, 1979		
1	OFF	"500"
2	ISLS	OFF
3	OFF	"LA BASIN"
4	OFF	"500"
5	ISLS	OFF
6	OFF	"LA BASIN"
June 12, 1979		
7	OFF	"500"
8	ISLS	OFF
9	OFF	"1000"
10	ISLS	OFF
11	OFF	"500"

Note: TFAST: SLS
ASR-4: ISLS
EFAST: OFF

DATA REDUCTION AND ANALYSIS.

The suppression data collected for each of the flights were reduced as described in appendix A and then plotted and listed for further analysis and comparison. The individual plots for each of the runs are shown in figures 2 through 12 and correspond to the sequence shown in table 1.

Each of the graphs have been plotted with respect to time; each point being the average of 40 one-eighth second samples or an average of five seconds of data. The range of the aircraft from NAFEC as shown on each graph is a close approximation to the actual range. The scale has not been corrected for the small variations which occur in the flight time for each of the 30-mile legs.

The test runs also showed remarkable repeatability as evidenced in figures 13 through 17. Because of the different antenna patterns of the two aircraft used in conducting the tests, no attempt was made to compare the results from the two days when using the same test configurations. Further, weather and soil conditions prior to and during the flights were quite different and contributed to the variations in the vertical lobing patterns and thus the overall suppression counts.

Examination of the data generally showed a pronounced dip when the aircraft was directly over the DABS/TRBTF site because it was in the cone of silence. At this point the suppression levels were due mostly to the TFAST and the ASR-4 site. As the aircraft proceeded outbound the suppression rates increased very rapidly and peaked within the first three miles from NAFEC. Data from the FIM listings in this region are shown in table 2 below. Except for the rates for DABS "1000", the suppression rates in all cases were lower using the DABS sensor than when the TRBTF was operating normally with ISLS.

TABLE 2. SUMMARY OF SUPPRESSION RATES WITHIN THREE MILES OF NAFEC

	May 7			June 12		
Test Condition	Run #	5 Sec Peak	0-3 mi Avg	Run #	5 Sec Peak	0-3 mi Avg
ATCRBS	2	1019	811	8	754	628
	5	937	839	10	716	608
DABS "500"	1	632	535	7	544	365
	4	642	535	11	696	476
DABS "LA BASIN"	3	688	580			
	6	805	636			
DABS "1000"				9	1099	692

The suppression levels shown in table 2 can also be equated to a transponder availability time. As an example, a transponder being suppressed at a peak rate of 1019 suppressions per second as in run 2 would be suppressed for 45855 microseconds (assuming a 45 microsecond transponder suppression time) or for approximately 4.6% of the time. This in itself is not an exceptionally high suppression rate and is consistent with the environment today wherein transponders typically operate with round reliabilities of 90 to 95 percent. Reducing the peak suppression rate to 805 (run 6) or to 642 (run 4) suppressions per second would suppress the transponder for only 3.6% or 2.9% of the time.

In the DABS "1000" case, the average suppression level exceeded the ATCRBS baseline (i.e., without DABS in the environment) because the aircraft was close to the DABS site and in the sidelobe region. As the test aircraft proceeded outbound, the suppression rates dropped to a level below the ATCRBS baseline. Even though this case was unrealistic in the sense that the DABS average interrogation rate used was in excess of the rate that would be experienced in a high-densiity operational environment, it shows that, except for the sidelobe region which is less than 2% of the airspace of interest, the

suppression level with DABS in the environment is still lower than today's ATCRBS environment at NAFEC. In the sidelobe region, an ATCRBS transponder would be suppressed for an average of 4.9% of the time compared to 3.4% for the ATCRBS baseline on the same day. The 1.5% difference in round reliability, when translated into probability of detection and code validation for reply processors would produce no noticeable effect.

Further examination of the graphs show that as the aircraft proceeded outbound beyond three miles, the suppression rates decreased rather rapidly and had leveled off by the time the ten mile point had been reached. This would indicate that the aircraft was beyond the range of the side lobes of the TFAST (which operated only with SLS) antenna and the DABS antenna when one of the DABS configurations was used. In the region between three and ten miles some of the stronger side lobes exceeded the FIM receiver thresholds which resulted in varying suppression count levels. At ranges beyond ten miles the recorded suppression rates were the sum total from all ATCRBS sites within line-of-sight of the aircraft. In all cases, the suppression levels at these ranges were reduced when the "ATCRBS" configuration was replaced by the "DABS" configuration. During the DABS configurations this amounted to main beam suppressions from DABS interrogations. Assuming a nominal transmit beam width of 4°, the DABS sensor contributed 26 interrogations per scan (4.7 sec) when the DABS "500" configuration was used and 52 interrogations per scan with the DABS "1000" configuration. This is considered to be a small proportion of the overall suppression rate.

Direct comparisons of the suppression rates in the airborne environment when an ATCRBS facility operates using ISLS as compared to when that facility is replaced by a DABS sensor are shown in figures 18 and 19. In both figures, the higher of the two plots were obtained when the TRBTF was interrogation with ISLS. The lower plots were obtained using the DABS "500" configuration. It is evident that there is a considerable reduction in the suppression rate when an ATCRBS facility is replaced with a DABS sensor.

REPLY PROCESSOR FRUIT SUSCEPTIBILITY TESTS.

Several of the ATCRBS reply processors currently being used by FAA to process radar beacon data have been tested to determine their susceptibility to DABS fruit. To date the ARTS III Beacon Data Acquisition Subsystem (BDAS) has been completely tested, and the ARTS II and the TPX-42 processors have been partially tested. All processors were tested using a digital defruiter. Those processors that still remain to be tested included the Production Common Digitizer (PCD or AN/FYQ-47) and the ARTS IIIa Sensor Receiver and Processor, Type I (SRAP-I).

DESCRIPTION OF EQUIPMENT.

ARTS III. The Automated Radar Terminal System (ARTS III) converts beacon video into digital target reports. It is a modular design incorporating a

hardware Beacon Data Acquisition Subsystem (BDAS), and Input/Output Processor (IOP), a digital tape drive, a teletype, a common equipment cabinet and a display.

The Beacon Data Acquisitions Subsystem (BDAS) is a hard-wired beacon processor that performs (on a sweep basis) azimuth decoding, mode trigger recognition, bracket detection, identity and altitude code pulse recognition, garble sensing, and transfer of the aforementioned data to the IOP for subsequent processing.

The input/output processor (IOP) is a general type computer that provides for the expansion of the computer memory core in 8K word modules. The system at the NAFEC TFAST presently employs a memory size of 32K words. The IOP accepts azimuth, replies, and status information words from the BDAS. It performs target detection, target tracking, display functions, and keyboard input functions from the controller, and outputs data functions to the ARTS III display and the online teletypewriter.

The display provides the capability of presenting (1) raw beacon, (2) raw radar normal and moving target indicator (MTI) videos, (3) BDAS bracket decodes, (4) digital targets as detected by the IOP program, (5) target tracks, (6) system data, and (7) alphanumeric information for targets and target tracks. The keyboard associated with the display permits direct communication by an operator with the IOP program.

The common equipment inputs radar trigger, azimuth change pulses (ACPs), and the azimuth reference pulse (ARP). These signals are used to derive the range marks ans sweep for the ARTS III display.

The tape drive is required to load (1) the operational program, (2) diagnostics for the IOP and peripheral equipments, and (3) special utility programs into the IOP. It is also used to extract various types of data from the IOP such as beacon replies, target reports, track data, and keyboard entries. It also provides the capability of dumping the contents of the IOP memory onto magnetic tape.

ARTS II. The ARTS II system is an ATCRBS processor consisting of a hardware unit and a 16 bit minicomputer. The hardware unit detects ATCRBS replies from the beacon video and transfers position, mode, and detected identity and altitude code information to the minicomputer. The minicomputer performs beacon input processing, display functions, system monitoring, tracking, and keyboard input processing. It is capable of driving up to 11 displays and processing input from up to 22 keyboards. The minicomputer is also capable of recording target and reply data onto digital magnetic tape. The memory is expandable in 32K segments up to 256K.

AN/TPX-42A The AN/TPX-42A (V4) is a hardware beacon video processor used by the FAA. The AN/TPX-42A receives beacon video, mode triggers and beacon sync from ATCBI equipment. Radar pretrigger and synchro data is received from primary radar. These input signals are processed by the AN/TPX-42A to provide bracket video and synthetic target data. The synthetic target data is transferred as output messages to display equipment to display position, code and altitude of transponder-equipped aircraft.

MX-8757/UPX INTERFERENCE BLANKER. This is a digital defruiter which is designed to eliminate asynchronous replies. It does this by delaying all of the pulses in one PRF and then comparing them with those in the next PRF. The pulses that are not coincident in each period are eliminated. Defruiters are normally used at all terminal facilities to eliminate fruit prior to processing.

DABS FRUIT GENERATOR. The DABS fruit generator is a hardware unit fabricated at NAFEC to simulate DABS fruit replies. It is capable of generating DABS fruit rates from 0 to 2,000 replies per second in 4 replies per second increments. Selection of the percentage of extended length message DABS replies (112 μs), short DABS message replies (56 μs), and selection of desired reply codes and percentage mixture of the selected codes are programmable features. The unit also accepts as input ATCRBS video and mixes and outputs combined DABS fruit and ATCRBS video. The unit is described in detail in appendix B.

ATCRBS TARGET/FRUIT GENERATOR. The ATCRBS target/fruit generator is a hardware unit fabricated at NAFEC which is capable of generating simulated ATCRBS targets, nonsynchronous ATCRBS fruit replies, and internally generated azimuth change pulses and azimuth reference pulses The ATCRBS targets can be varied in range, azimuth, identity and altitude codes, run length and round reliability. The number of targets per scan, the ATCRBS fruit rates, the run length distribution and the overall round reliability of the targets are all programmable features built into the unit. The azimuth generator is capable of simulating various antenna speeds. See appendix C for a detailed description of the unit.

TEST PROCEDURES.

The ATCRBS target/fruit generator and the DABS fruit generator were used as the target and fruit sources for each of the tests. The typical data set described on page 22 in appendix C was used in conjunction with DABS fruit rates of 0, 10, 20, 40, 75, 100, 200, 400, 750 and 1,000 replies per second to provide a complete test scenario. Based upon the 1982 and 1995 traffic models, it is not expected that DABS fruit rates in excess of 75 replies per second will be experienced when DABS is implemented. Nonetheless, tests at high DABS fruit rates were conducted so as to provide continuity of data and to assure consistent operation of each reply processor tested. Each of the processors were tested using a digital defruiter and optimum parameter settings as would normally be used at operational field facilities. Target and fruit replies from the two generators were injected into the defruiter the same as they would have been received from the receiver quantizers of either an ATCBI-4 or ATCBI-5 interrogator/receiver unit.

DATA REDUCTION AND ANALYSIS.

PERCENT DETECTION. The target reports collected for the test runs on each of the processors were reduced and analyzed as described briefly below. Probability of detection was determined by searching for targets at the precise

locations in range and azimuth where they were generated by the special test equipment. Percent detection is the ratio of the number of targets found to the number of targets generated. The results for percent detection for the ARTS III, the ARTS II and the TPX-42 as tested with various combinations of ATCRBS and DABS fruit rates are shown in tables 3, 7, and 11, respectively. Examination of the tables indicates that there are no differences between the baseline data (percent detection obtained without DABS fruit) and the data obtained at various DABS fruit levels. The small differences that are observed in percent detection are due to variations in the synchronization between the fruit generators and the target generator.

CODE VALIDATION. Code validation data was determined by counting the number of correct codes processed for each of the targets generated and detected. The results for each of the processors (the ARTS III, the ARTS II and the TPX-42) are shown in tables 4, 8 and 12, respectively.

Examination of the baseline data (i.e., without DABS fruit) indicates that code validation is very high and with no significant differences at ATCRBS fruit rates up to 5K replies per second. At ATCRBS fruit rates of 10K, the ARTS III shows a small amount of degradation, the ARTS II shows somewhat less, and the TPX-42 none at all.

Examining the data at various DABS fruit rates and comparing it with the baseline data indicates that there was no degradation to code validation at DABS fruit rates up to 400 replies per second. It should be noted that this rate was far in excess of the expected DABS fruit rate for the Los Angeles (LA) Basin models. It was only at very high fruit rates that some degradation became evident.

TARGET SPLITS. Target splits were determined by detecting two targets at the same location where only one was generated. Examination of the data shown in tables 5, 9, and 13 indicates that the increase in target splits was insignificant at DABS fruit rates up to 400 per second. As with code validation, it was only at very high fruit rates that an increase in target splits became evident.

FALSE ALARMS. As for false alarms, examination of the data in tables 6, 10 and 14 indicates that false alarms were practically non-existent except at very high fruit rates.

REPLY PROCESSOR PERFORMANCE AS A FUNCTION OF ROUND RELIABILITY.

A series of tests were conducted to determine how the ARTS III reply processor performed at various transponder round reliabilities. The resultant data is shown in tables 15 through 18. It is evident upon comparing the baseline data (obtained without DABS fruit) with the data at 200 DABS fruit replies per second that there are no differences in performance. As with all of the data, and as previously mentioned, the small variations observed are due to variations in the synchronization of the fruit generators with the target generator.

To compare the performance of each of the processors, data on each were selected from identical test conditions and presented in table 19. The test conditions selected, i.e., an ATCRBS fruit rate of 5,000 replies per second and a DABS fruit rate of 75 replies per second were near the maximum realistically expected in a mixed ATCRBS/DABS environment. Examination of this data indicates that there was no degradation in the performance of these processors.

SUMMARY

Tests are being conducted at NAFEC to determine what effect the implementation of DABS, will have on the performance of ATCRBS, and to verify the predictions and conclusions contained in the interference analysis presented in FAA Report FAA-RD-78-147.

Uplink tests were made to measure transponder suppression rates in the ATCRBS airborne environment under various ATCRBS and DABS ground interrogator site configurations. One set of test were conducted while the three ATCRBS sites at NAFEC were operating in a normal mode of operation. The Eastern Region's commissioned facility, the ASR-4 site, and the TRBTF transmitted using ISLS while the TFAST used only SLS. A second set of tests were conducted with the DABS sensor replacing the TRBTF and operating at near-maximum capacity. The resultant data was then examined and the suppression rates of the various configurations compared.

In most cases examined to date, DABS "1000" being the exception, the number of suppressions received while using DABS as a replacement for ATCRBS was lower than while using the three facilities in a normal ATCRBS configuration. The resultant effect of less suppressions is to increase transponder round reliability making each transponder more available to reply to other interrogations, and in general, to improve the ATCRBS airborne environment.

In addition to the uplink measurements, tests were conducted on some of the reply processors being used by the FAA in operational facilities to process ATCRBS targets. The processors tested were the ARTS III, the ARTS II and the TPX-42 in conjunction with a digital defruiter. The tests were designed to determine processor susceptibility to DABS fruit interference. Using specialized equipment specifically designed to simulate the ATCRBS environment, the processors were subjected to performance tests both with and without DABS fruit interference. The data obtained without the DABS fruit interference were used as a baseline and compared with the performance data obtained with various levels of DABS fruit. Such examination failed to indicate any significant differences in the performance of the processors tested.

CONCLUSIONS

The following conclusions are based on a partial set of comprehensive experimental tests and validate a portion of Lincoln Laboratory's theoretical interference analysis:

1. The uplink tests conducted to date demonstrate that the replacement of ATCRBS facilities with DABS sensors will not degrade the ATCRBS airborne environment, and will in fact result in an improvement.

2. The reply processors (with defruiting) tested to date are not susceptible to DABS fruit interference and that no degradation will be experienced by the implementation of DABS.

		ATCRBS FRUIT RATE					
		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	99.17	99.18	99.05	98.61	98.46	98.56
	10	98.37	98.49	98.45	98.46	98.49	98.54
	20	99.06	98.57	98.45	98.35	98.57	99.29
DABS	40	99.26	98.63	98.56	98.44	98.58	98.57
Fruit	75	98.42	99.17	98.39	99.09	99.18	98.59
Rate	100	99.06	98.48	98.48	99.12	99.27	98.52
	200	99.09	99.11	98.51	99.24	98.57	98.67
	400	98.47	98.41	98.44	98.40	98.40	98.47
	750	98.70	98.68	98.54	99.24	98.62	98.68
	1000	98.62	98.60	98.61	99.29	98.58	98.78

TABLE 3. ARTS III PERCENT DETECTION

		ATCRBS FRUIT RATE					
		0	.5 K	1.0 K	2.5K	5.0K	10.0K
	0	96.9	96.7	96.6	96.3	96.2	95.4
	10	96.7	96.9	97.0	96.6	96.1	95.2
	20	97.2	96.8	96.9	96.4	95.8	95.0
DABS	40	96.7	96.6	96.4	96.0	96.1	94.8
Fruit	75	96.5	96.4	96.6	96.5	96.3	95.0
Rate	100	96.7	96.6	96.5	96.5	95.9	94.6
	200	96.4	96.5	96.4	96.4	95.8	94.3
	400	96.3	96.2	95.3	96.0	95.3	93.7
	750	95.1	94.9	95.7	95.4	94.1	91.5
	1000	94.7	94.6	95.0	95.0	93.9	92.2

TABLE 4. ARTS III CODE VALIDATION

		ATCRBS FRUIT RATE					
		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	.57	.57	.63	.52	.67	.60
	10	.73	.62	.67	.67	.69	.99
	20	.61	.67	.55	.64	.74	.99
DABS	40	.65	.67	.71	.81	.75	.99
Fruit	75	.74	.68	.55	.65	.71	.94
Rate	100	.54	.53	.57	.56	.60	.67
	200	.73	.71	.60	.61	.63	.87
	400	.64	.52	.80	.78	1.05	1.27
	750	1.35	1.47	1.01	.81	1.28	1.51
	1000	1.29	1.29	1.10	.87	.85	1.31

TABLE 5. ARTS III TARGET SPLITS PER SCAN

		ATCRBS FRUIT RATE					
		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	0	0	0	0	0	.05
	10	0	0	0	0	0	.07
	20	0	0	0	0	0	.05
DABS	40	0	0	0	0	0	.12
Fruit	75	0	0	0	0	0	.08
Rate	100	0	0	0	0	0	.12
	200	0	0	0	.01	.01	.20
	400	0	0	0	.03	.12	.80
	750	0	.01	.02	.03	.11	.77
	1000	.03	.07	.12	.23	.70	2.75

TABLE 6. ARTS III FALSE ALARMS PER SCAN

ATCRBS FRUIT RATE

		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	99.88	99.80	99.80	99.80	99.77	99.82
DABS	10	99.70	99.68	99.66	99.71	99.67	99.70
Fruit	20	99.69	99.57	99.76	99.65	99.76	99.71
Rate	40	99.71	99.68	99.71	99.68	99.60	99.78
	75	99.60	99.67	99.65	99.66	99.65	
	100	99.64	99.52	99.77	99.61	99.67	99.73

TABLE 7. ARTS II PERCENT DETECTION

ATCRBS FRUIT RATE

		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	99.2	98.5	98.1	98.1	98.0	97.3
DABS	10	98.1	98.0	98.3	98.3	97.9	97.3
Fruit	20	98.2	98.3	98.1	98.1	97.6	96.8
Rate	40	98.4	97.9	98.1	98.0	97.9	97.0
	75	98.0	98.2	98.1	97.9	97.8	
	100	97.9	98.1	98.2	98.0	97.7	96.8

TABLE 8. ARTS II CODE VALIDATION

ATCRBS FRUIT RATE

		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	0	.01	.05	.08	.17	.45
DABS	10	0	.03	.01	.12	.15	.31
Fruit	20	.02	.03	.03	.09	.19	.38
Rate	40	.03	.01	.01	.08	.19	.57
	75	.04	.03	.07	.14	.20	
	100	.08	.09	.08	.13	.23	.48

TABLE 9. ARTS II TARGET SPLITS PER SCAN

ATCRBS FRUIT RATE

		0	.5 K	1.0 K	2.5K	5.0K	10.0K
	0	0	0	0	.01	.02	.25
DABS	10	0	0	0	.01	.01	.18
Fruit	20	0	0	0	0	0	.30
Rate	40	0	0	0	0	.01	.25
	75	0	0	0	0	.02	
	100	0	0	0	.01	.02	.37

TABLE 10. ARTS II FALSE ALARMS PER SCAN

ATCRBS FRUIT RATE

		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	99.16	99.15	99.15	99.13	99.16	99.16
	10	99.11	99.11	99.12	99.12	99.14	99.14
DABS	20	99.16	99.15	99.15	99.16	99.18	99.18
Fruit	40	99.09	99.12	99.14	99.14	99.15	99.13
Rate	75	99.10	99.14	99.12	99.10	99.13	99.15
	100	99.12	99.13	99.14	99.15	99.13	99.15
	200	99.13	99.15	99.18	99.14	99.22	99.15
	400	99.20	99.16	99.16	99.18	99.26	99.30

TABLE 11. TPX-42 PERCENT DETECTION

ATCRBS FRUIT RATE

		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	99.9	99.9	99.9	99.9	99.8	99.6
	10	99.9	99.9	99.9	99.9	99.8	99.6
DABS	20	99.9	99.9	99.9	99.8	99.7	99.6
Fruit	40	99.9	99.9	99.9	99.9	99.8	99.5
Rate	75	99.9	99.9	99.9	99.9	99.9	99.4
	100	99.9	99.9	99.9	99.9	99.8	99.5
	200	99.9	99.9	99.9	99.9	99.7	99.4
	400	99.9	99.9	99.9	99.8	99.8	99.4

TABLE 12. TPX-42 CODE VALIDATION

		ATCRBS FRUIT RATE					
		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	.01	.01	.01	.01	.01	.04
	10	.02	.02	.02	.02	.04	.09
DABS	20	.01	.01	.01	.01	.01	.05
Fruit	40	.02	.02	.03	.02	.02	.05
Rate	75	.02	.02	.02	.03	.04	.06
	100	.02	.02	.02	.03	.02	.07
	200	0	.01	.01	.01	.03	.10
	400	.01	.01	.01	.03	.09	.14

TABLE 13. TPX-42 TARGET SPLITS PER SCAN

		ATCRBS FRUIT RATE					
		0	.5K	1.0 K	2.5K	5.0K	10.0K
	0	0	0	0	0	0	.01
	10	0	.01	0	0	0	.01
DABS	20	0	0	.01	0	.02	0
Fruit	40	.01	.01	0	.01	0	.01
Rate	75	0	0	0	0	.01	.02
	100	0	0	0	0	0	.02
	200	0	0	0	0	0	.01
	400	0	.01	0	.02	0	.03

TABLE 14. TPX-42 FALSE ALARMS PER SCAN

Round Reliability	DABS Fruit Rate	ATCRBS FRUIT RATE 0	.5K	1.0 K	2.5K	5.0K	10.0K
1.0	0	99.81	99.16	99.15	99.17		
1.0	200	99.81	99.19	99.84	99.19	99.84	99.15
0.91	0	99.17	99.18	99.05	98.61	98.46	98.56
0.91	200	99.09	99.11	98.51	99.24	98.57	98.67
0.83	0	96.83	96.84	96.53	97.45	96.88	97.00
0.83	200	96.85	96.83	97.48	96.86	97.51	96.85
0.75	0	92.42	92.60	92.04	92.14	92.94	92.47
0.75	200	92.06	92.40	92.09	92.85	92.23	92.82

TABLE 15. ARTS III PERCENT DETECTION

Round Reliability	DABS Fruit Rate	ATCRBS FRUIT RATE 0	.5 K	1.0 K	2.5K	5.0K	10.0K
1.0	0	99.0	99.1	99.0	99.0		
1.0	200	99.1	99.0	99.0	98.9	98.7	98.2
0.91	0	96.9	96.7	96.6	96.3	96.2	95.4
0.91	200	96.4	96.5	95.8	96.4	95.8	94.3
0.83	0	90.7	90.5	89.6	89.3	89.0	86.9
0.83	200	90.4	90.4	89.9	89.8	89.1	86.8
0.75	0	81.2	81.0	80.9	80.5	79.3	76.0
0.75	200	80.2	79.7	79.9	79.3	78.8	75.4

TABLE 16. ARTS III CODE VALIDATION

Round Reliability	DABS Fruit Rate	ATCRBS FRUIT RATE 0	.5K	1.0 K	2.5K	5.0K	10.0K
1.0	0	0	0	0	0		
1.0	200	.01	0	0	.01	.02	.14
0.91	0	.57	.57	.63	.52	.67	.60
0.91	200	.73	.71	.60	.61	.63	.87
0.83	0	1.39	1.35	1.33	1.47	1.48	1.57
0.83	200	1.45	1.48	1.42	1.42	1.47	1.59
0.75	0	1.43	1.47	1.49	1.44	1.49	1.69
0.75	200	1.40	1.45	1.38	1.43	1.47	1.67

TABLE 17. ARTS III TARGET SPLITS PER SCAN

Round Reliability	DABS Fruit Rate	ATCRBS FRUIT RATE 0	.5K	1.0 K	2.5K	5.0K	10.0K
1.0	0	0	0	0	.01		
1.0	200	0	0	0	01	.07	.29
0.91	0	0	0	0	0	0	0
0.91	200	0	0	0	.01	.01	.20
0.83	0	0	.01	.02	.02	.05	.25
0.83	200	.01	.04	.04	.03	.11	.35
0.75	0	0	.01	.01	.01	.01	.23
0.75	200	.01	.01	.04	.03	.07	.36

TABLE 18. ARTS III FALSE ALARMS PER SCAN

FAA PROCESSOR TEST RESULTS

	NO DABS		WITH DABS	
PROCESSOR	P_D	CODE VALIDATION	P_D	CODE VALIDATION
ARTS II	99.77	98.0	99.65	97.8
ARTS III	98.46	96.2	99.18	96.3
TPX-42	99.16	99.8	99.13	99.9

TEST CONDITIONS
75 DABS REPLIES/SEC
5000 ATCRBS/SEC
90% REPLY PROBABILITY
DEFRUITED

TABLE 19. COMPARISON OF PROCESSOR PERFORMANCE WITH AND WITHOUT DABS FRUIT

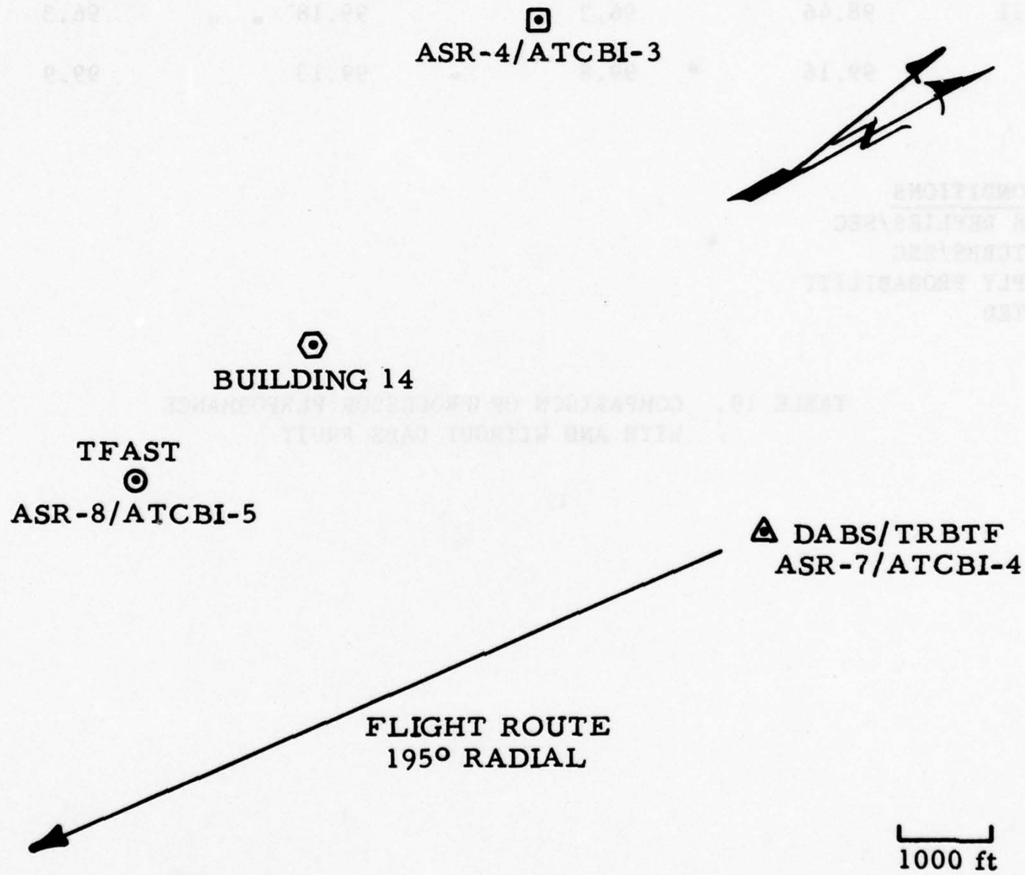

FIGURE 1. FLIGHT PLAN PROFILE

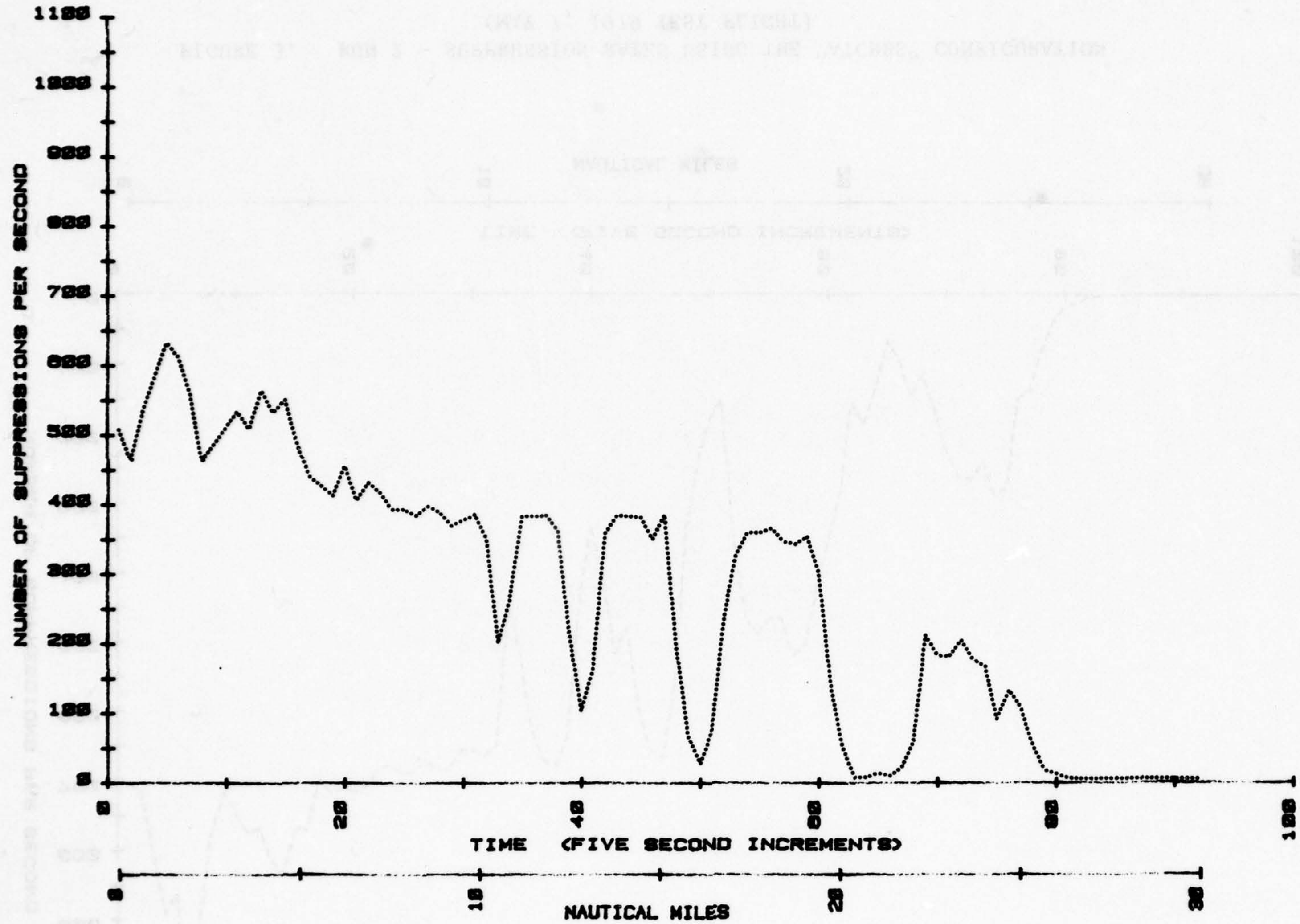

FIGURE 2. RUN 1 - SUPPRESSION RATES USING THE DABS "500" CONFIGURATION
(MAY 7, 1979 TEST FLIGHT)

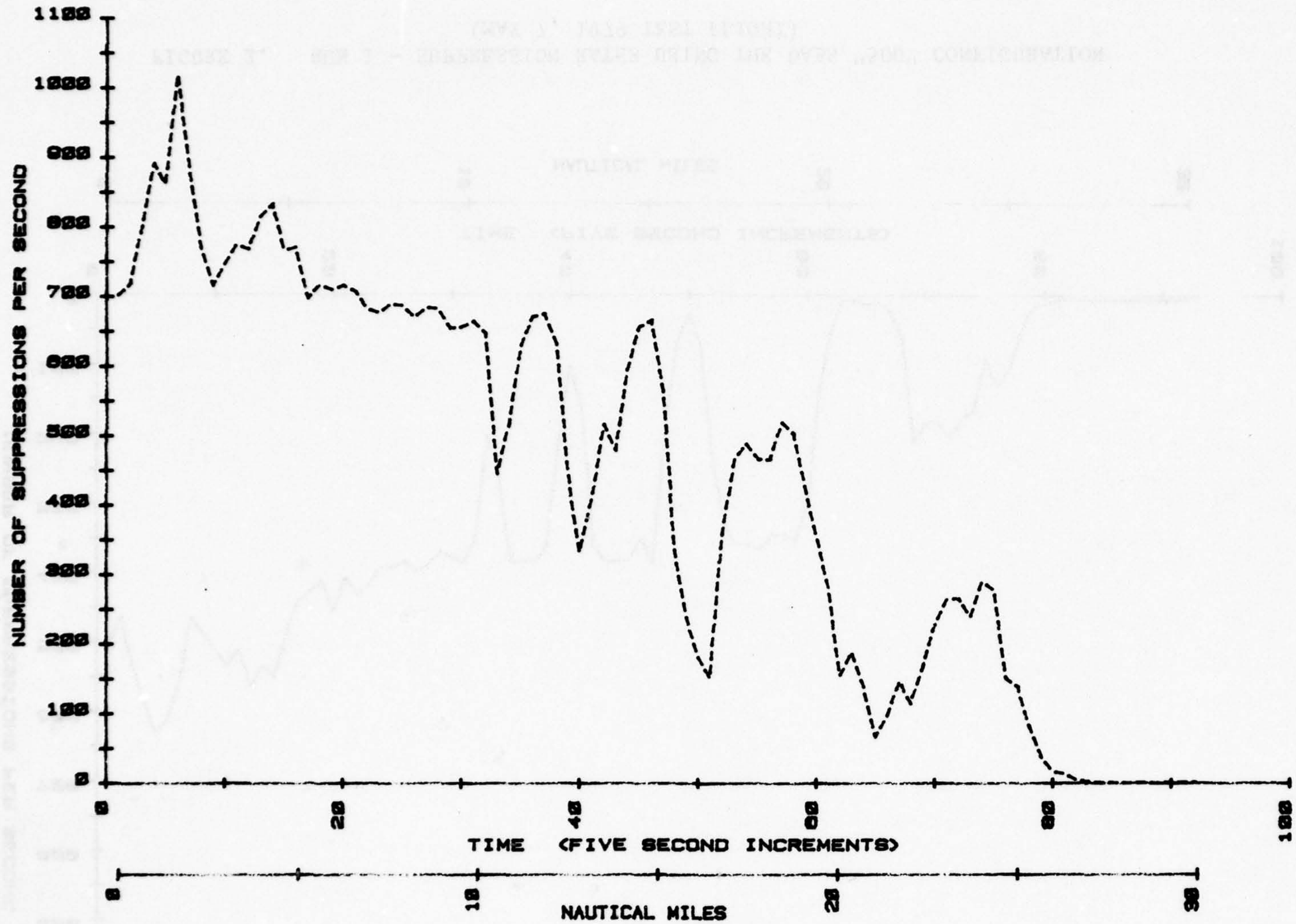

FIGURE 3. RUN 2 - SUPPRESSION RATES USING THE "ATCRBS" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

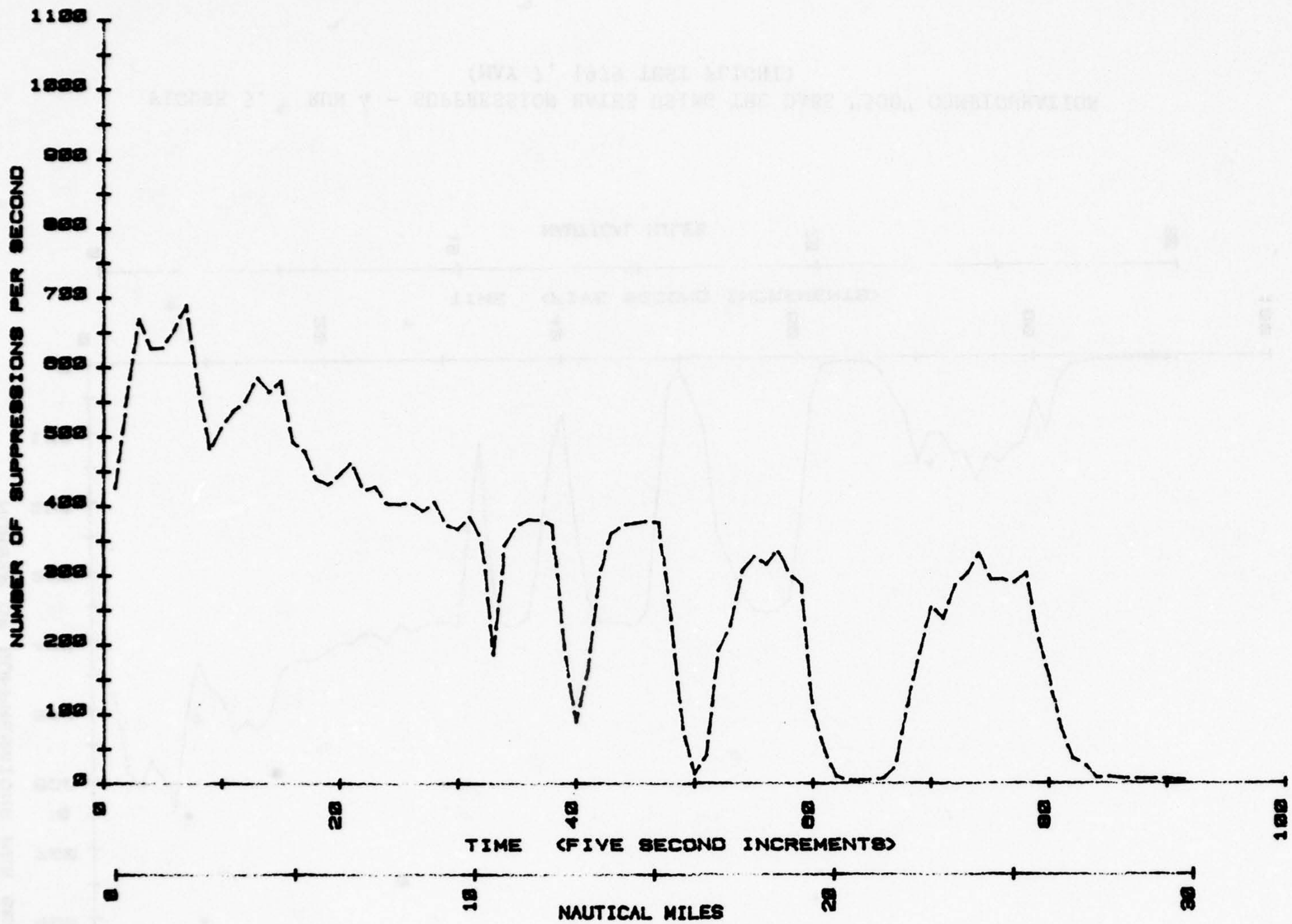

FIGURE 4. RUN 3 - SUPPRESSION RATES USING THE DABS "LA BASIN" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

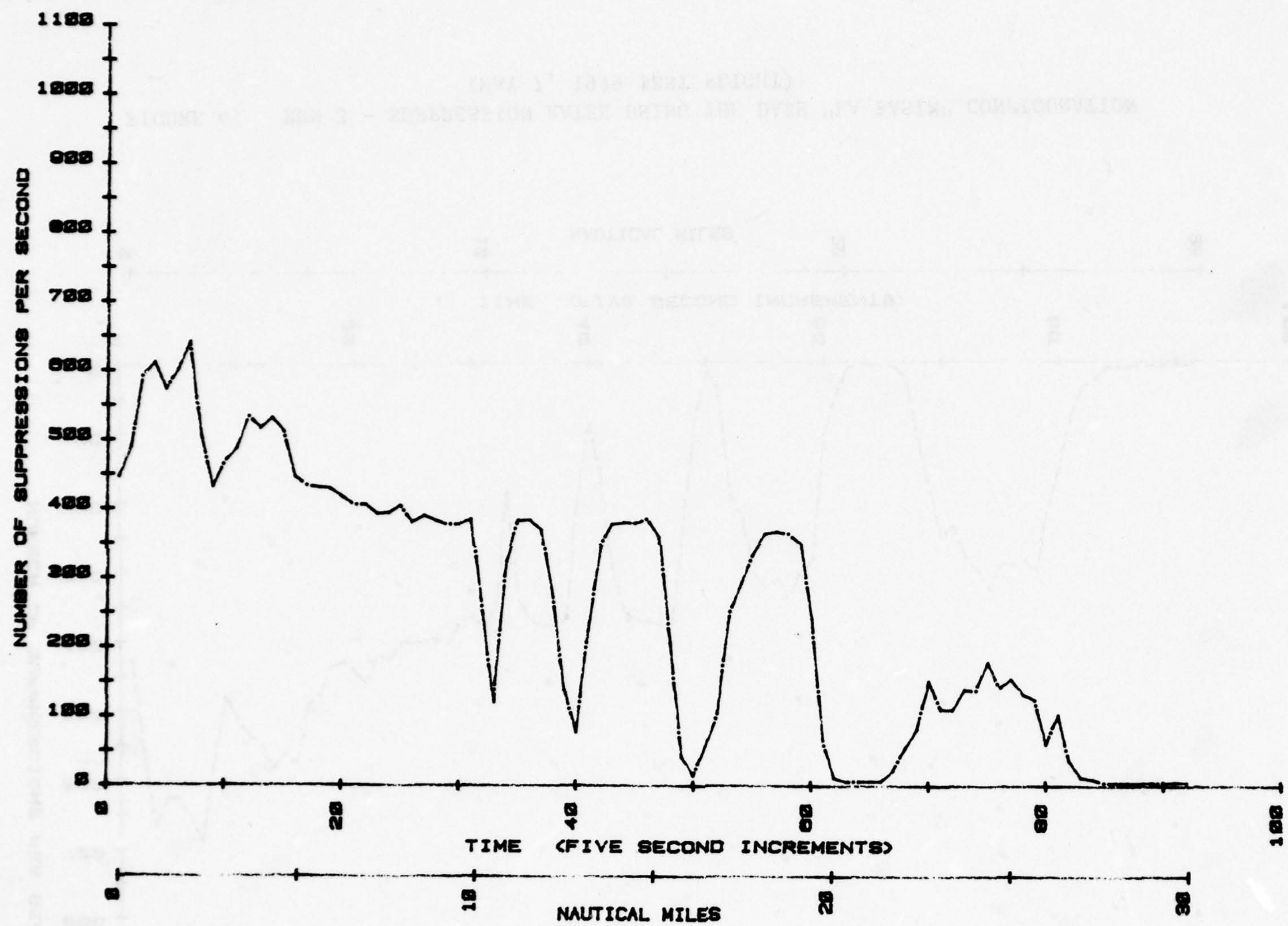

FIGURE 5. RUN 4 - SUPPRESSION RATES USING THE DABS "500" CONFIGURATION
(MAY 7, 1979 TEST FLIGHT)

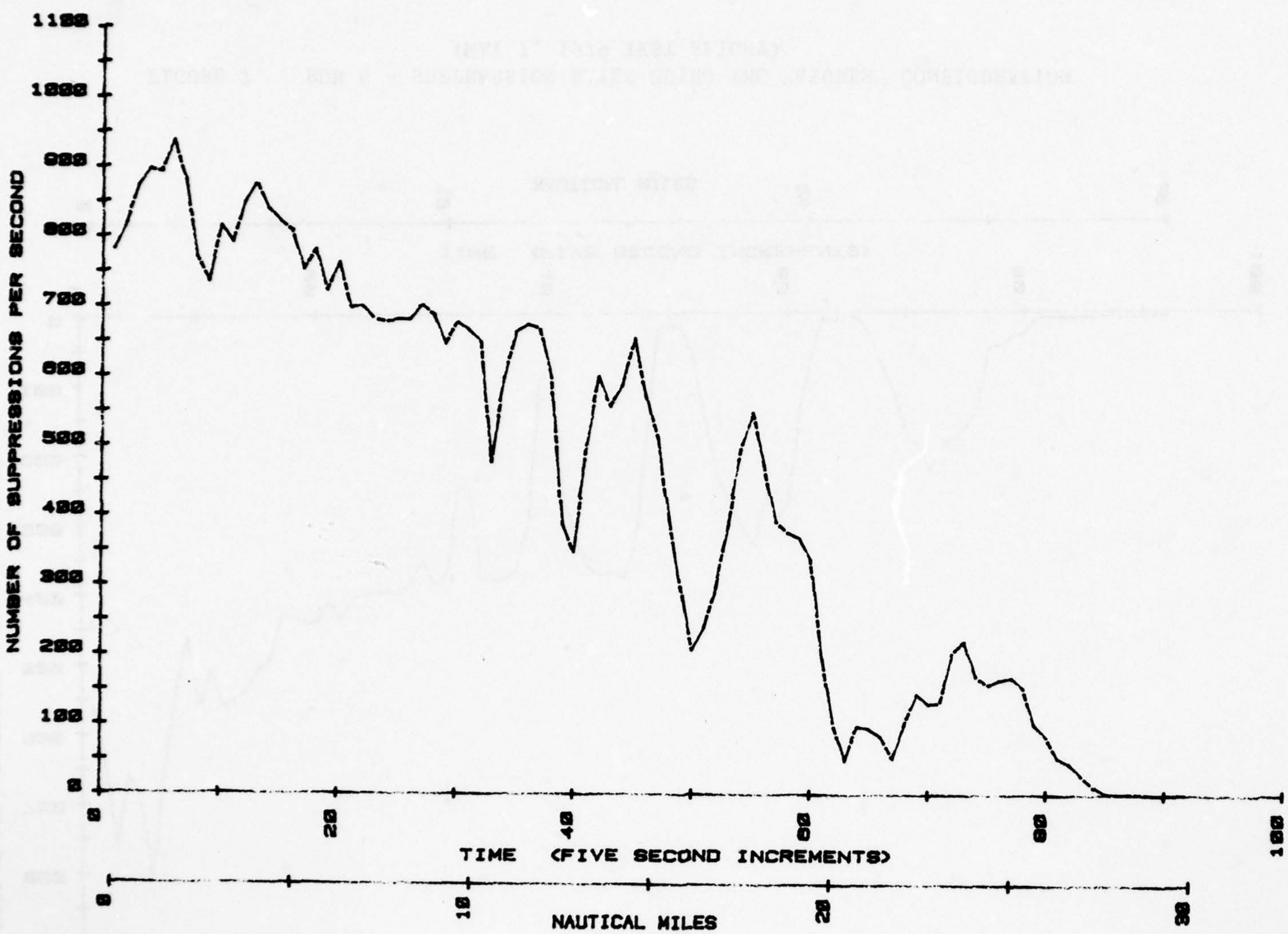

FIGURE 6. RUN 5 - SUPPRESSION RATES USING THE "ATCRBS" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

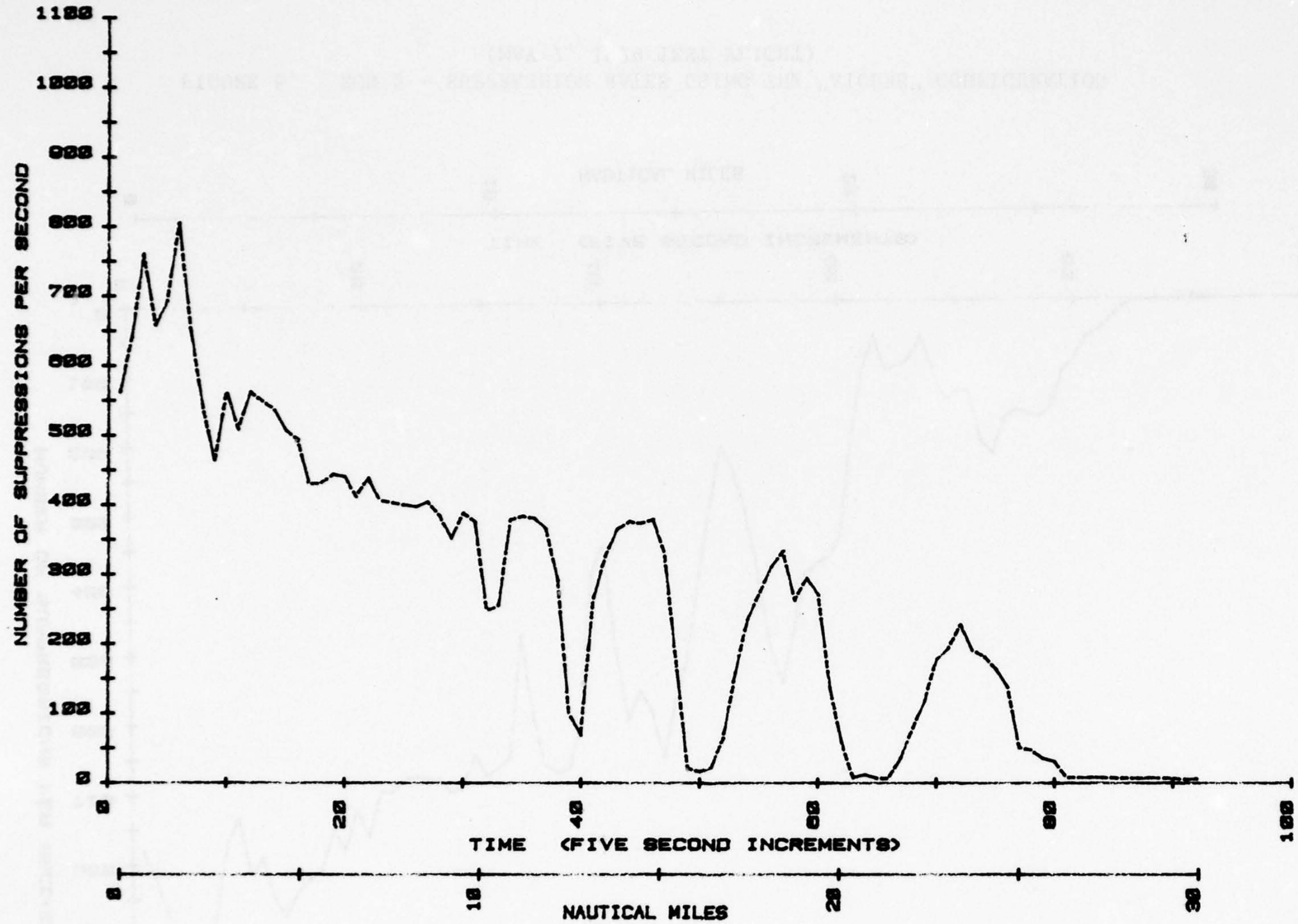

FIGURE 7. RUN 6 - SUPPRESSION RATES USING THE "ATCRBS" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

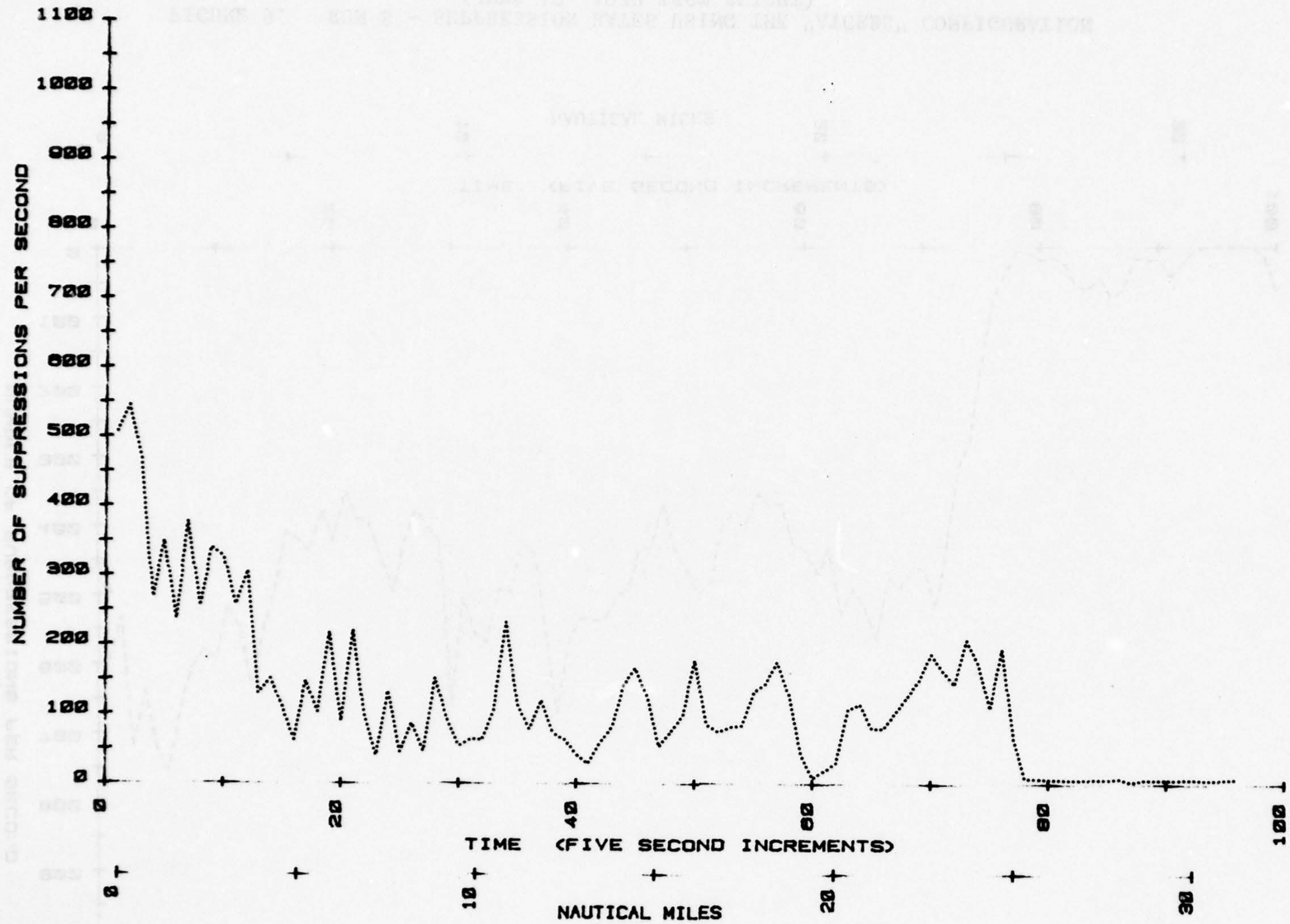

FIGURE 8. RUN 7 - SUPPRESSION RATES USING THE DABS "500" CONFIGURATION
(JUNE 12, 1979 TEST FLIGHT)

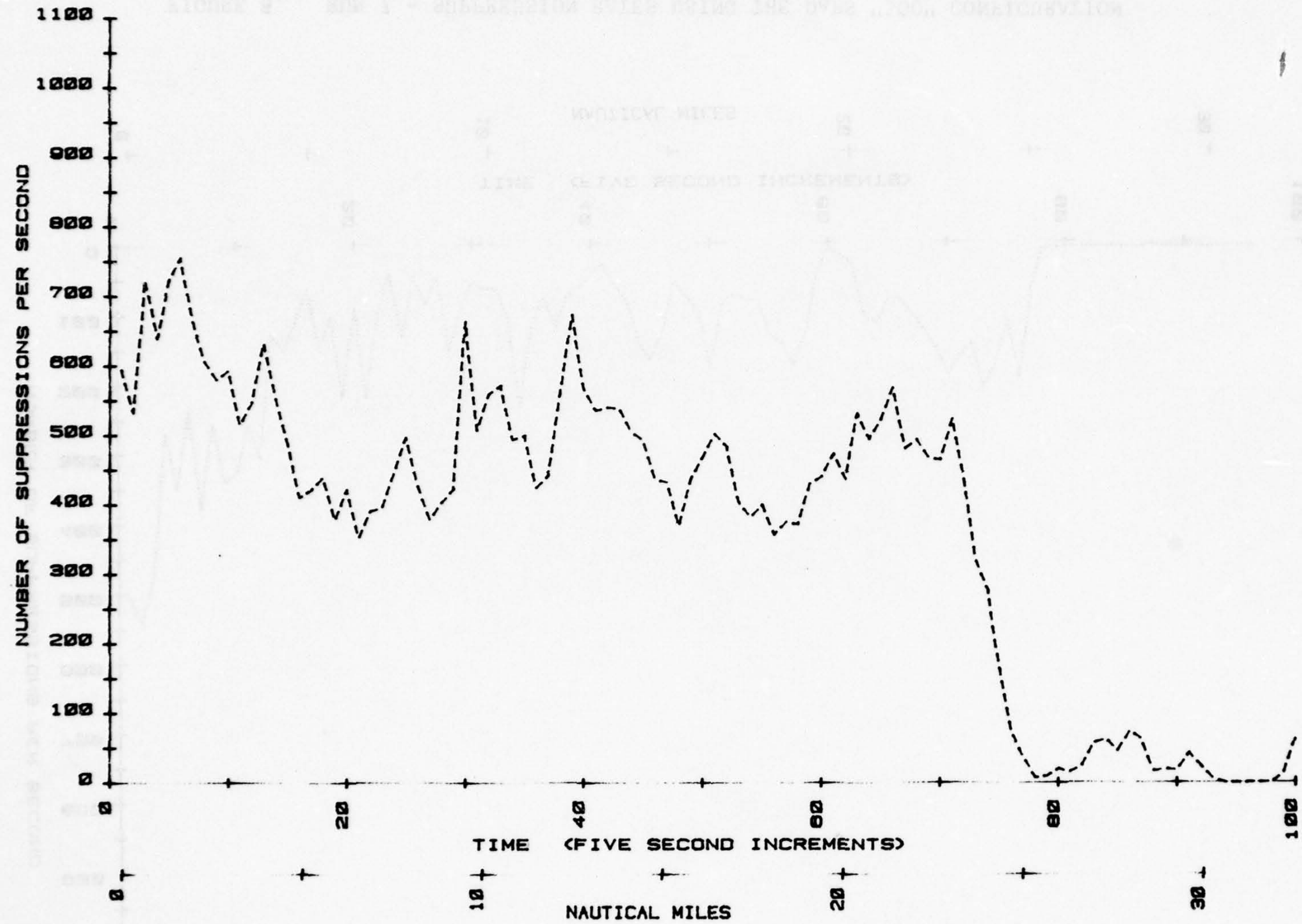

FIGURE 9. RUN 8 - SUPPRESSION RATES USING THE "ATCRBS" CONFIGURATION (JUNE 12, 1979 TEST FLIGHT)

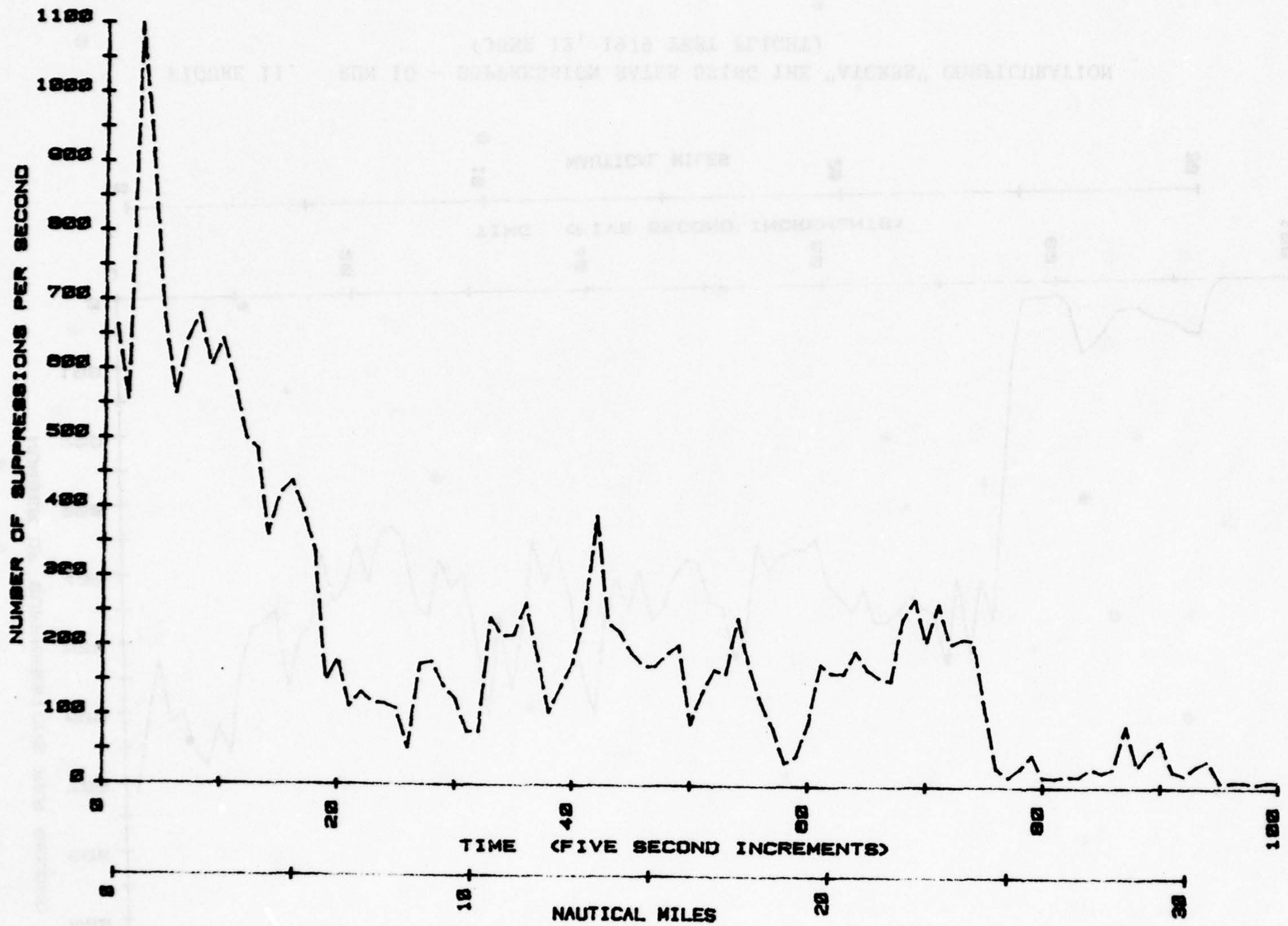

FIGURE 10. RUN 9 - SUPPRESSION RATES USING THE DABS "1000" CONFIGURATION (JUNE 12, 1979 TEST FLIGHT)

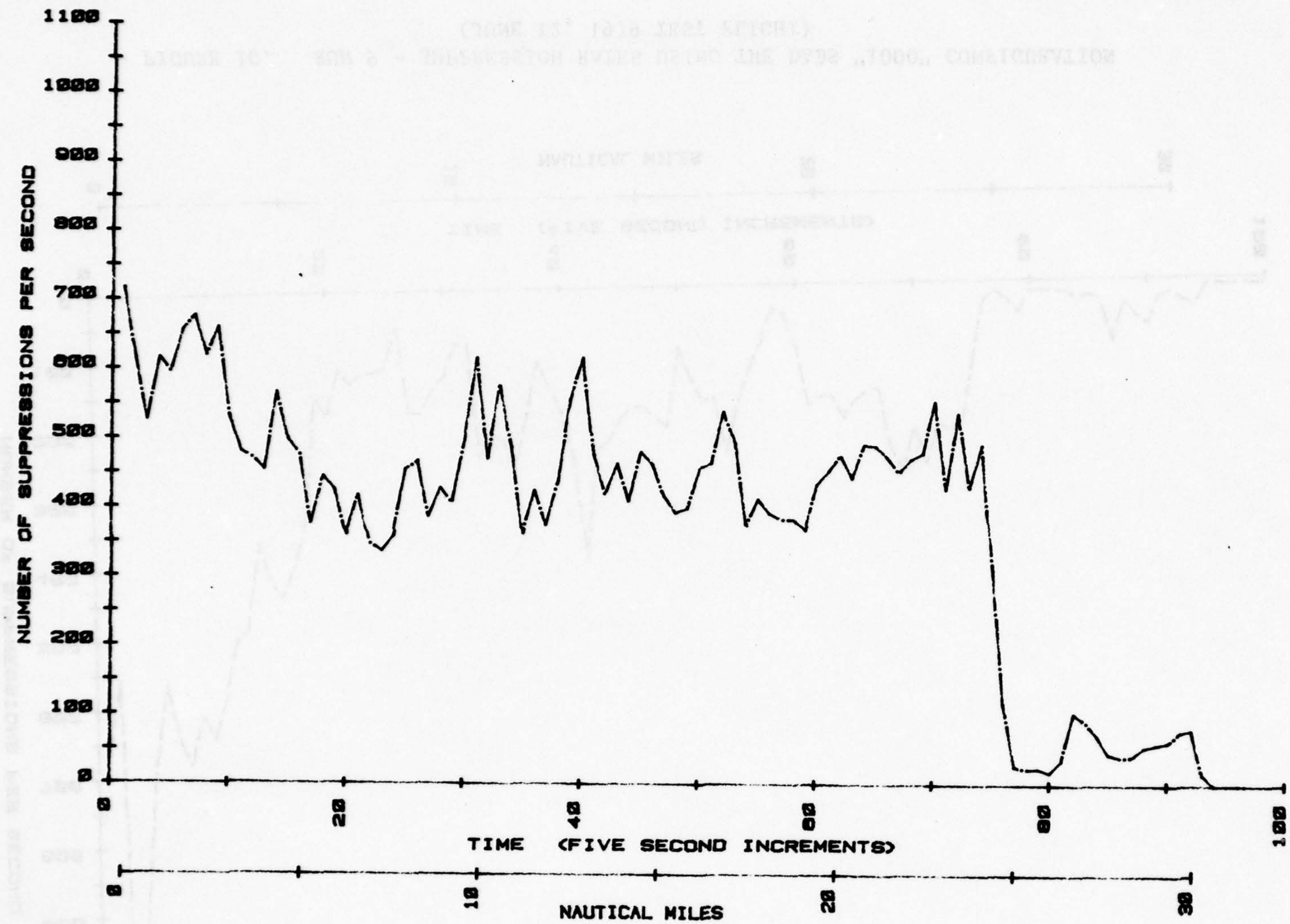

FIGURE 11. RUN 10 - SUPPRESSION RATES USING THE "ATCRBS" CONFIGURATION (JUNE 12, 1979 TEST FLIGHT)

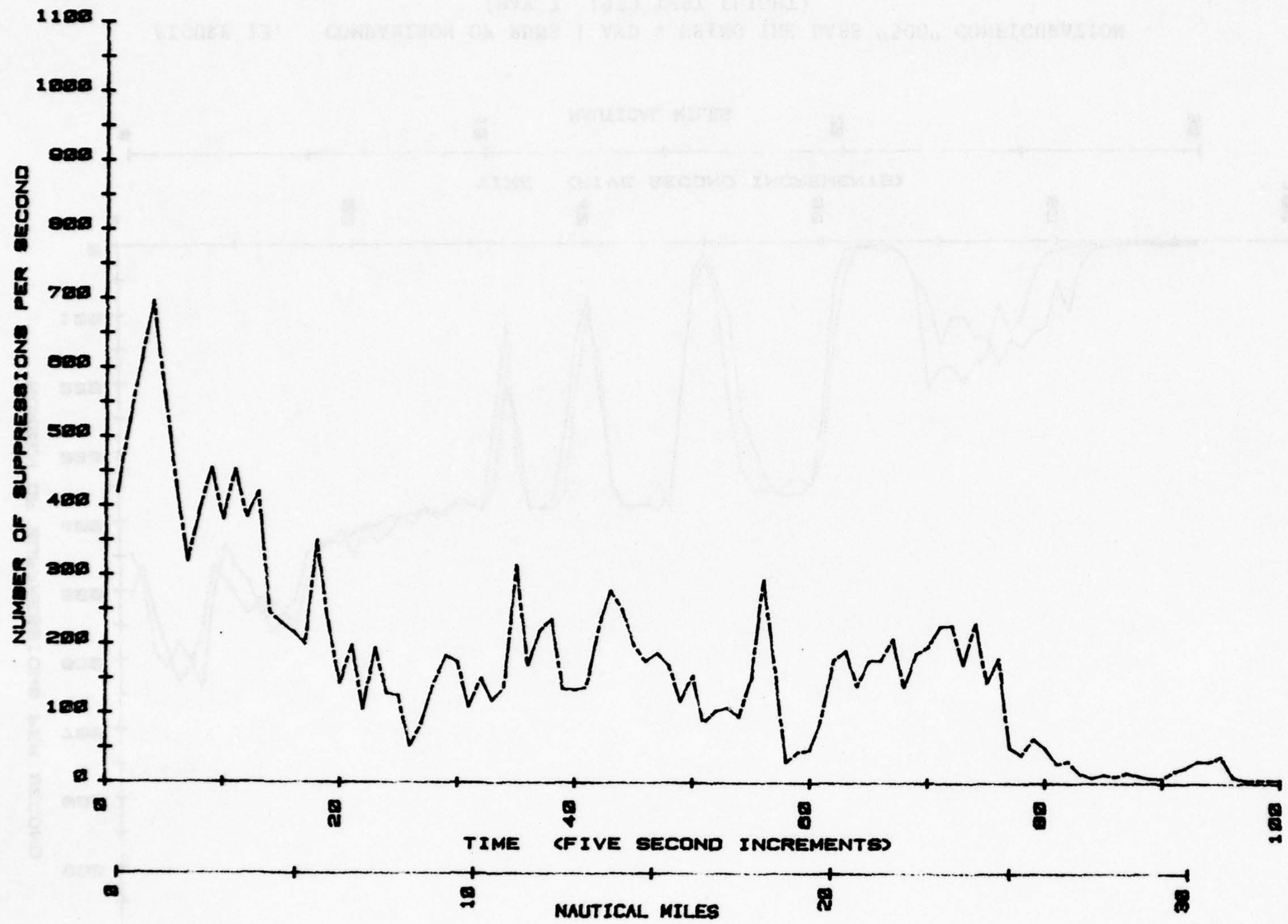

FIGURE 12. RUN 11 - SUPPRESSION RATES USING THE DABS "500" CONFIGURATION (JUNE 12, 1979 TEST FLIGHT)

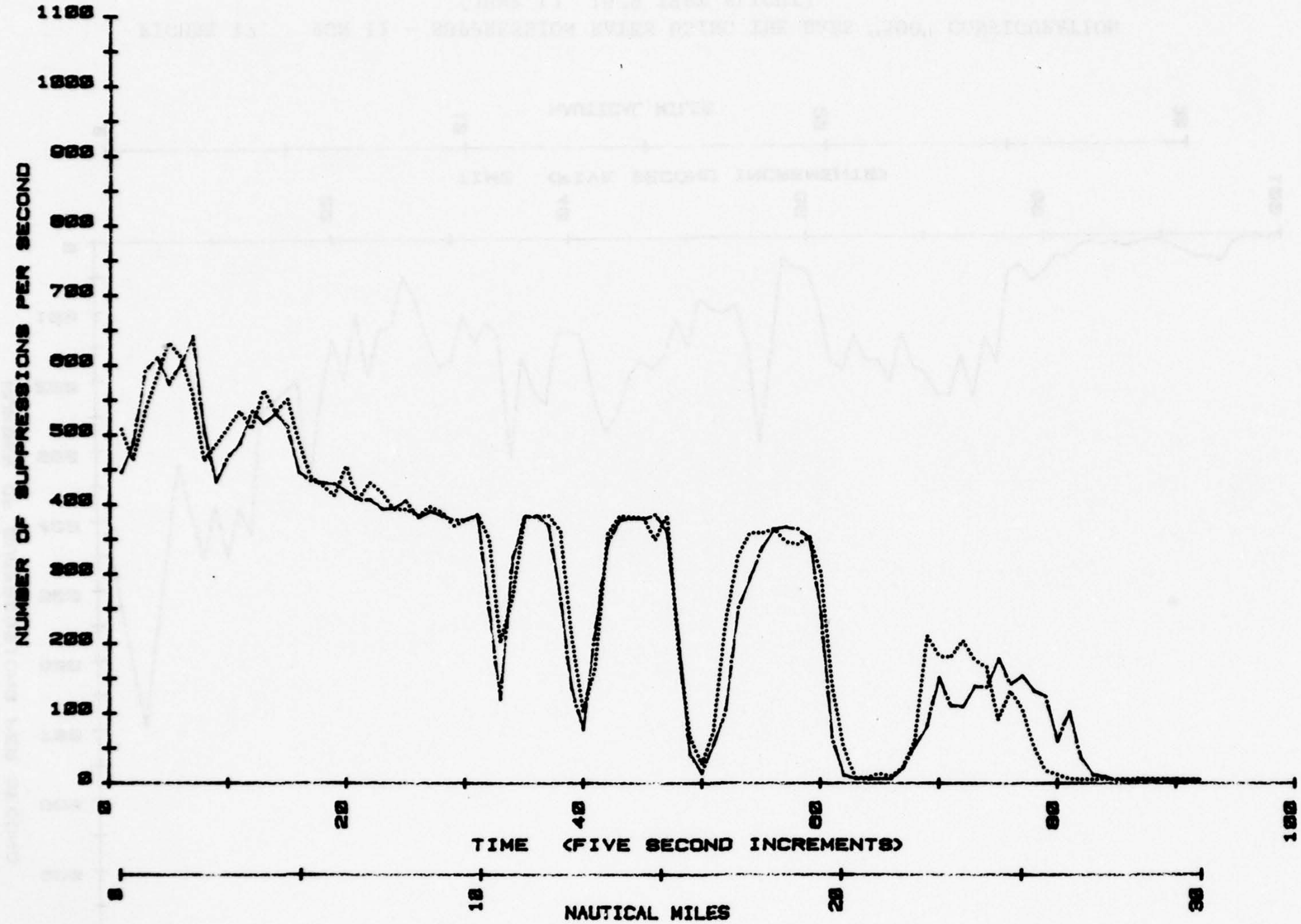

FIGURE 13. COMPARISON OF RUNS 1 AND 4 USING THE DABS "500" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

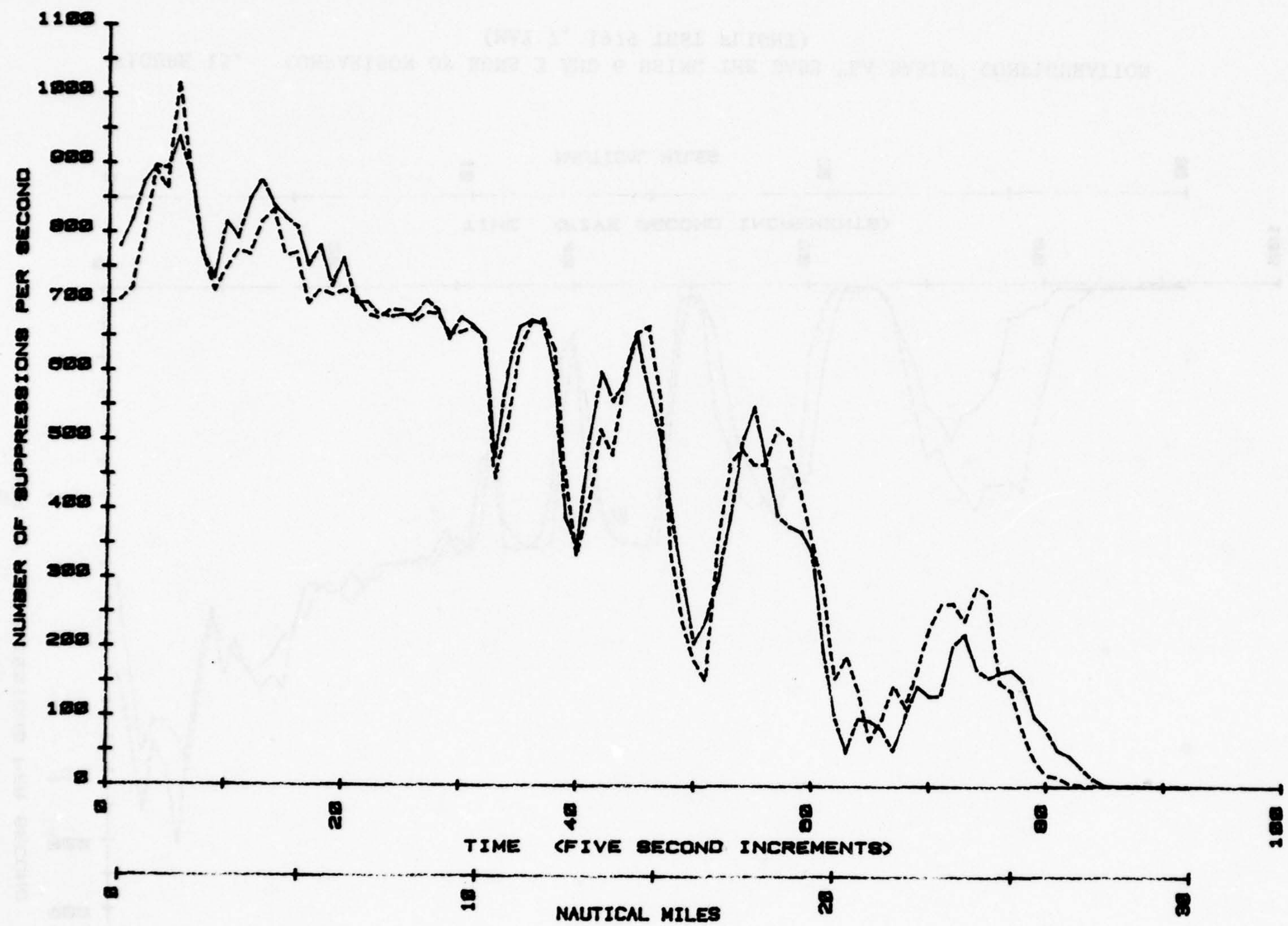

FIGURE 14. COMPARISON OF RUNS 2 AND 5 USING THE "ATCRBS" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

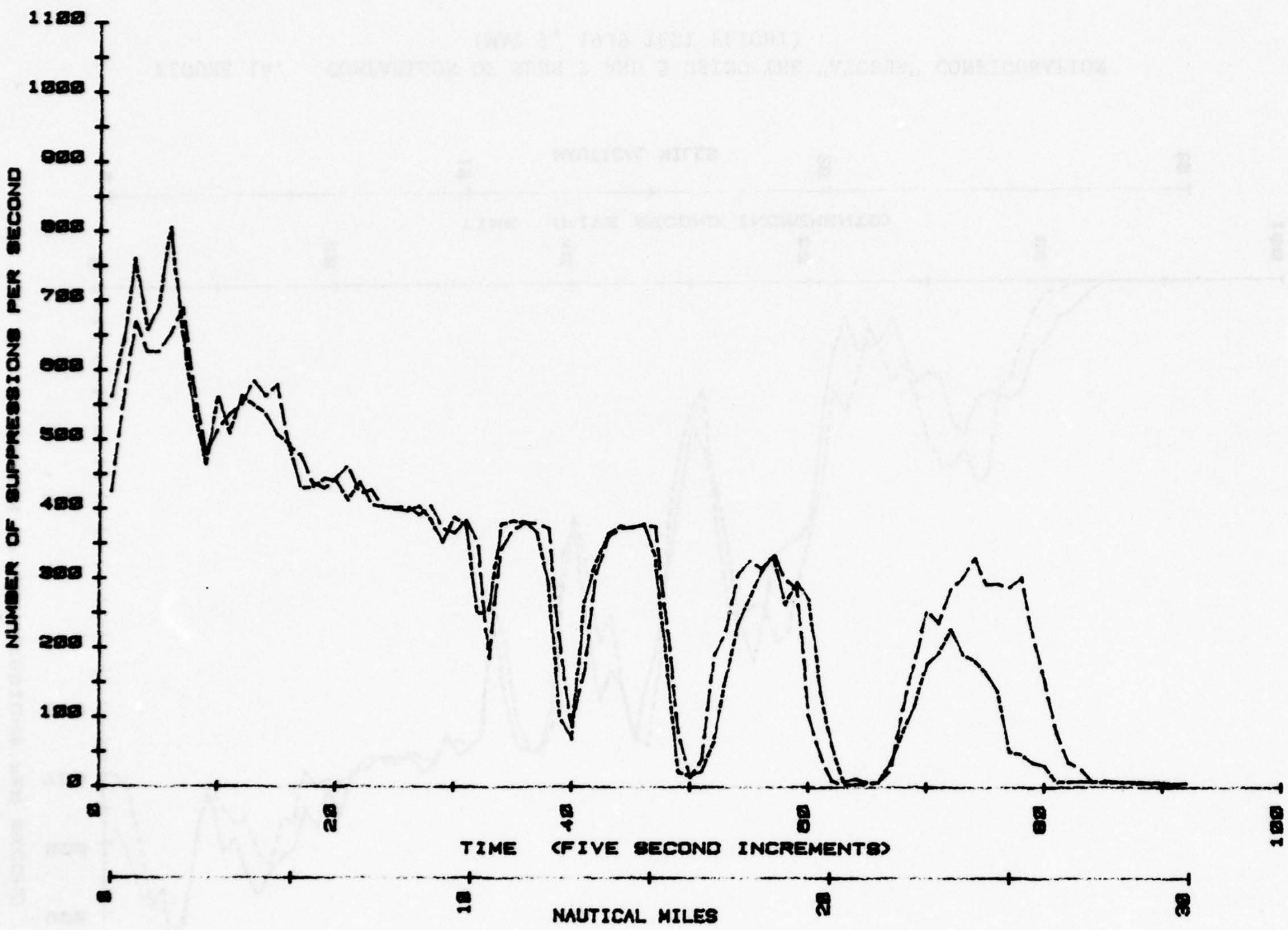

FIGURE 15. COMPARISON OF RUNS 3 AND 6 USING THE DABS "LA BASIN" CONFIGURATION (MAY 7, 1979 TEST FLIGHT)

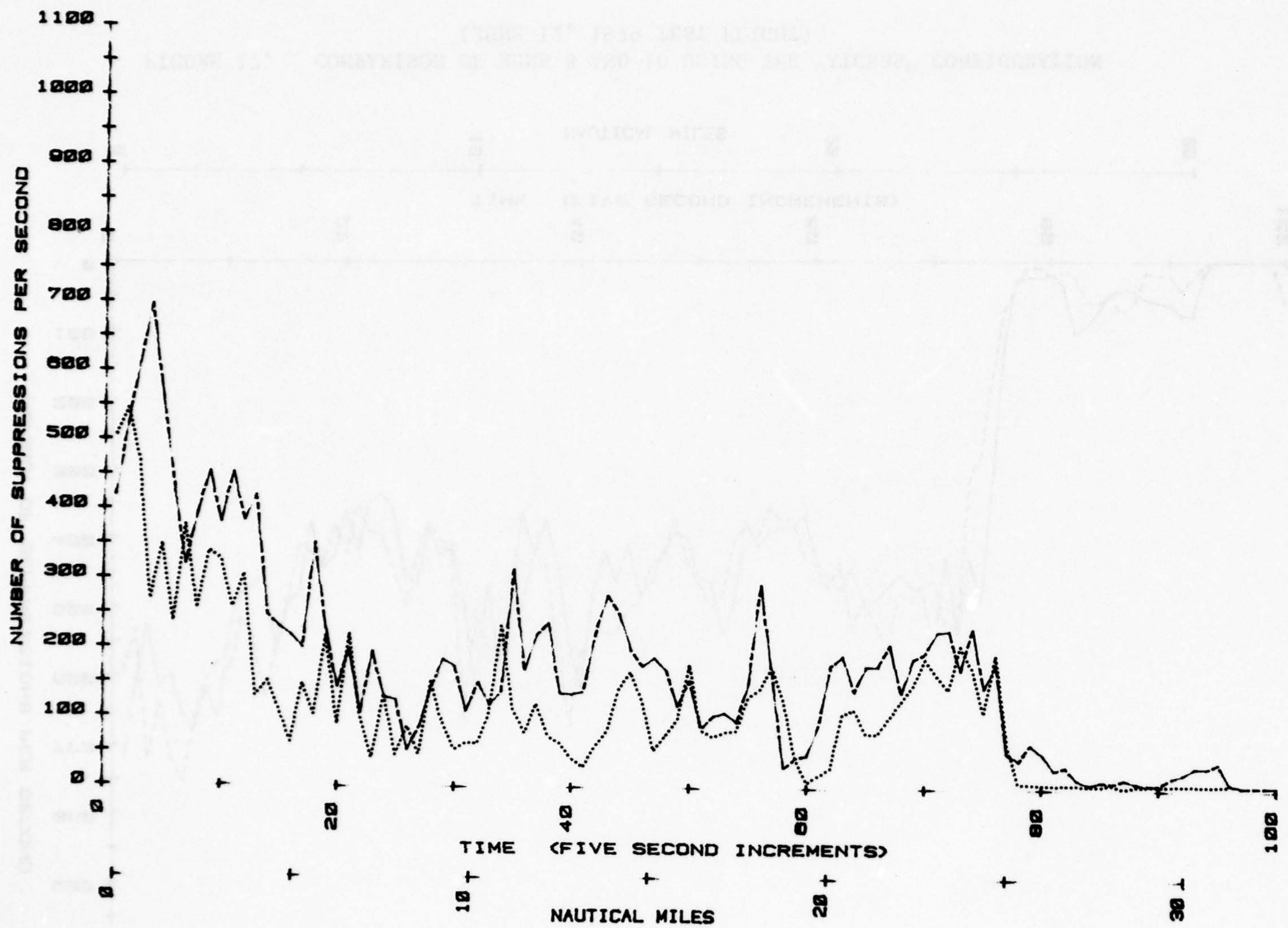

FIGURE 16. COMPARISON OF RUNS 7 AND 11 USING THE DABS "500" CONFIGURATION (JUNE 12, 1979 TEST FLIGHT)

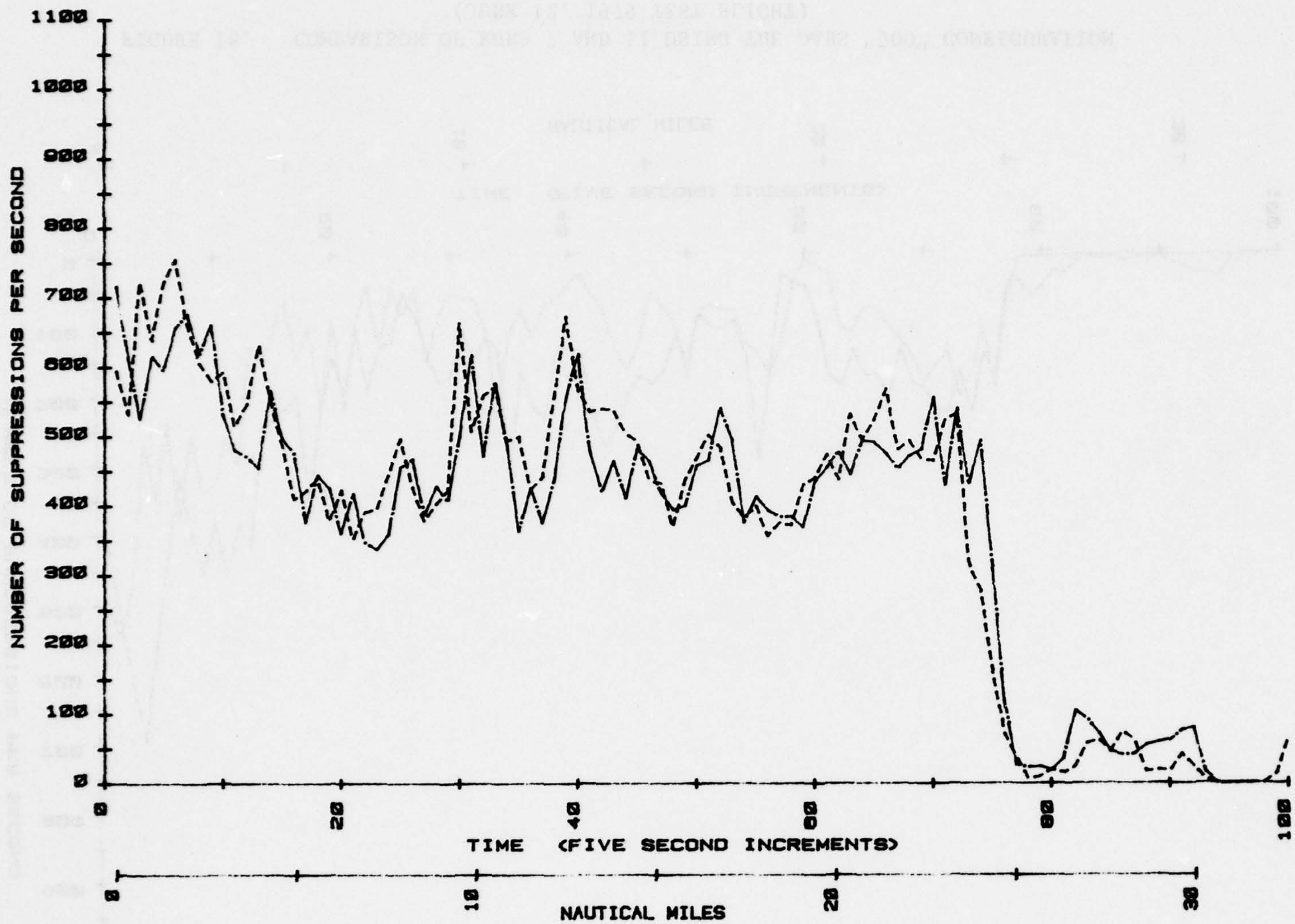

FIGURE 17. COMPARISON OF RUNS 8 AND 10 USING THE "ATCRBS" CONFIGURATION (JUNE 12, 1979 TEST FLIGHT)

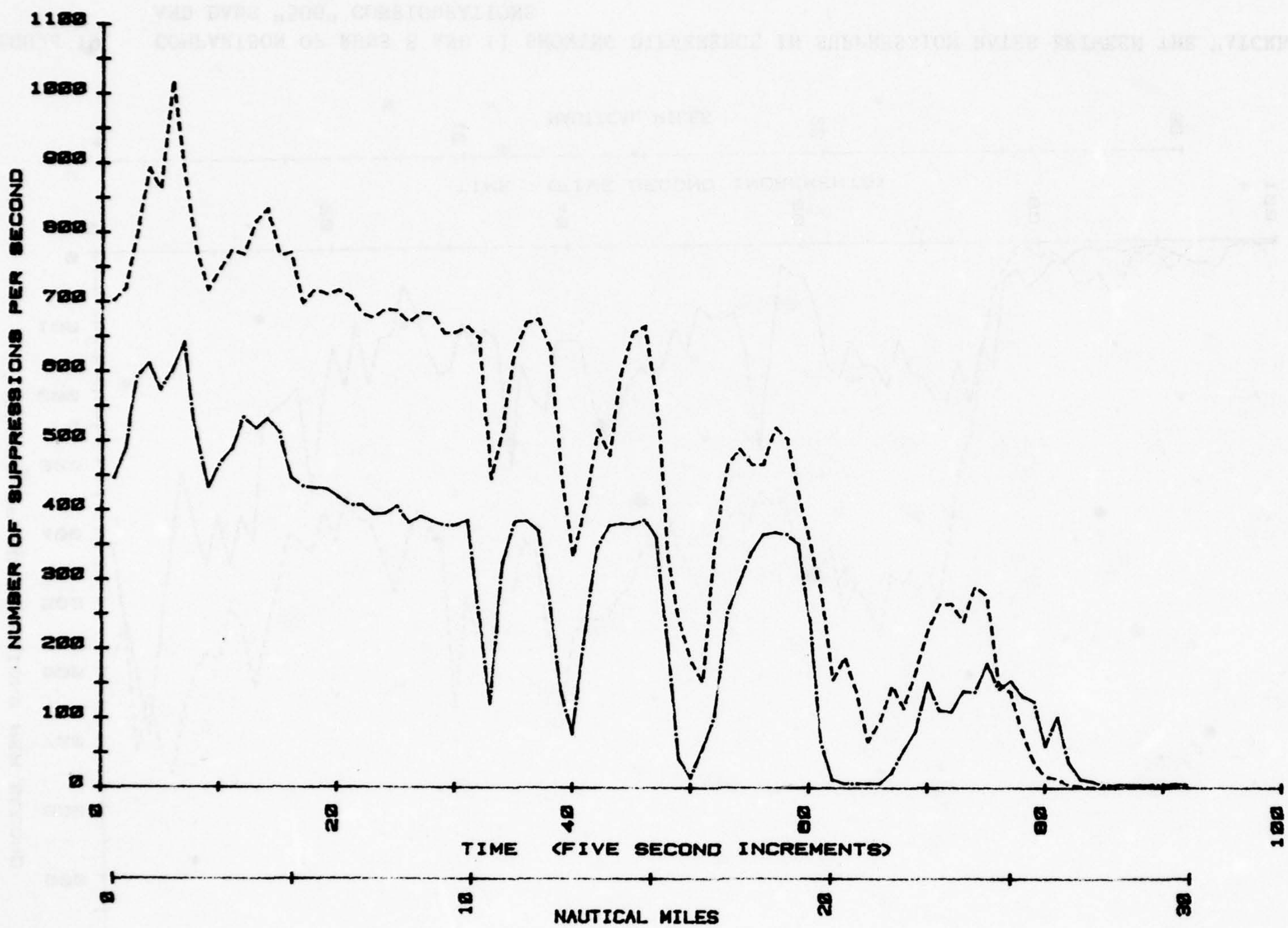

FIGURE 18. COMPARISON OF RUNS 2 AND 4 SHOWING DIFFERENCE IN SUPPRESSION RATES BETWEEN THE "ATCRBS" AND DABS "500" CONFIGURATIONS

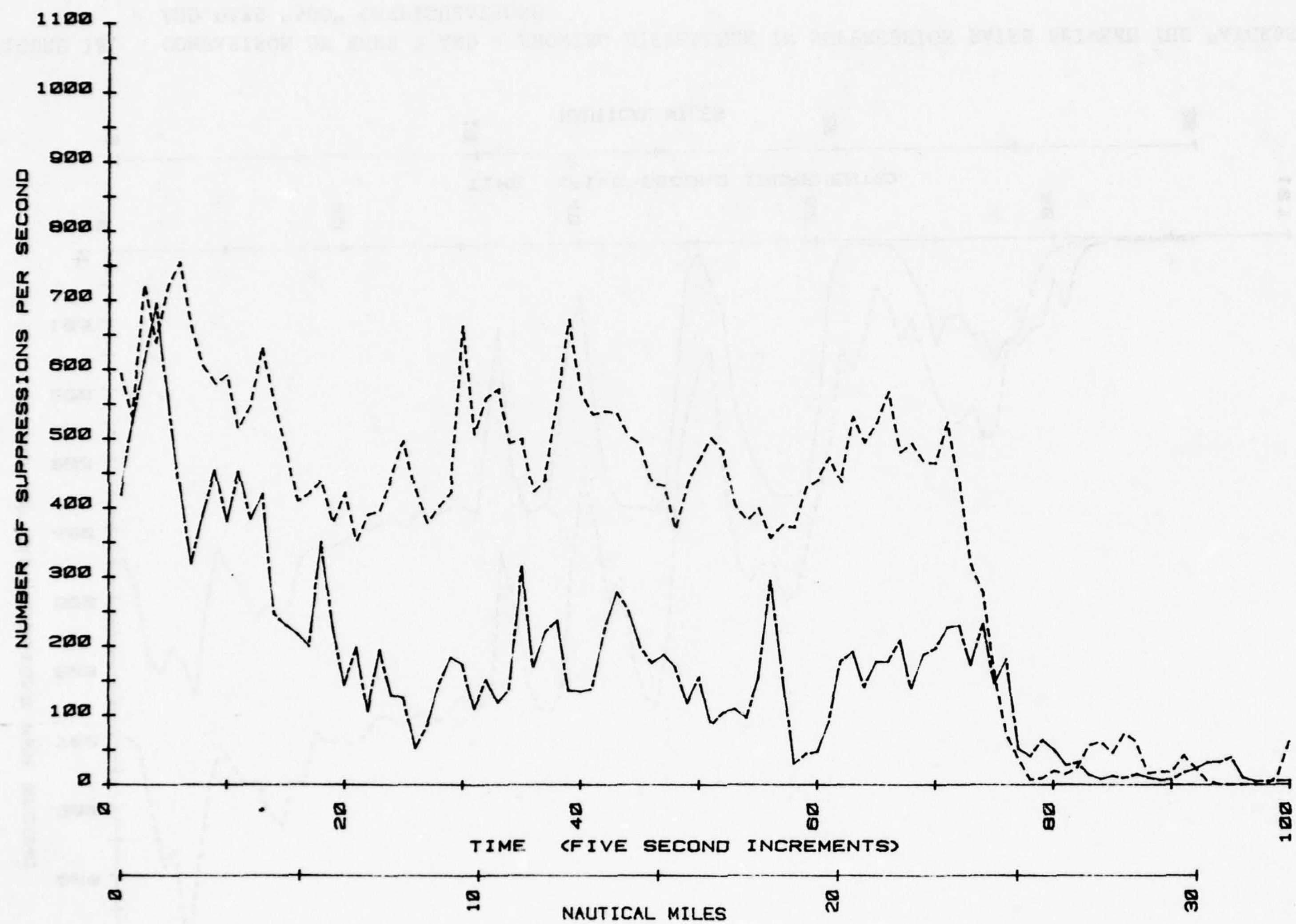

FIGURE 19. COMPARISON OF RUNS 8 AND 11 SHOWING DIFFERENCE IN SUPPRESSION RATES BETWEEN THE "ATCRBS" AND DABS "500" CONFIGURATIONS

APPENDIX A

FLIGHT INSPECTION MONITOR - TYPE 1

(FIM-I)

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FIM-I System

The FIM-I is an airborne environment performance monitor specifically designed for use on Federal Aviation Administration (FAA) semiautomated flight inspection (SAFI) aircraft. It consists of a receiver/processor, a digital magnetic tape recorder, and a dual-antenna installation. The system provides a measure of the ATCRBS interrogator environment by continuously recording the number of received interrogations. Provisions are included for recording elapsed time or the SAFI operations (OP) number so that data can be correlated with aircraft position. Front-panel controls allow selection of interrogation modes to be recorded, and a front-panel four-digit display allows in-flight monitoring of the interrogator environment. Detailed data analysis is obtained by postflight computer processing of the magnetic tape.

A functional block-logic diagram of the FIM-I system is shown in Figure A-1.

Receiver/Processor

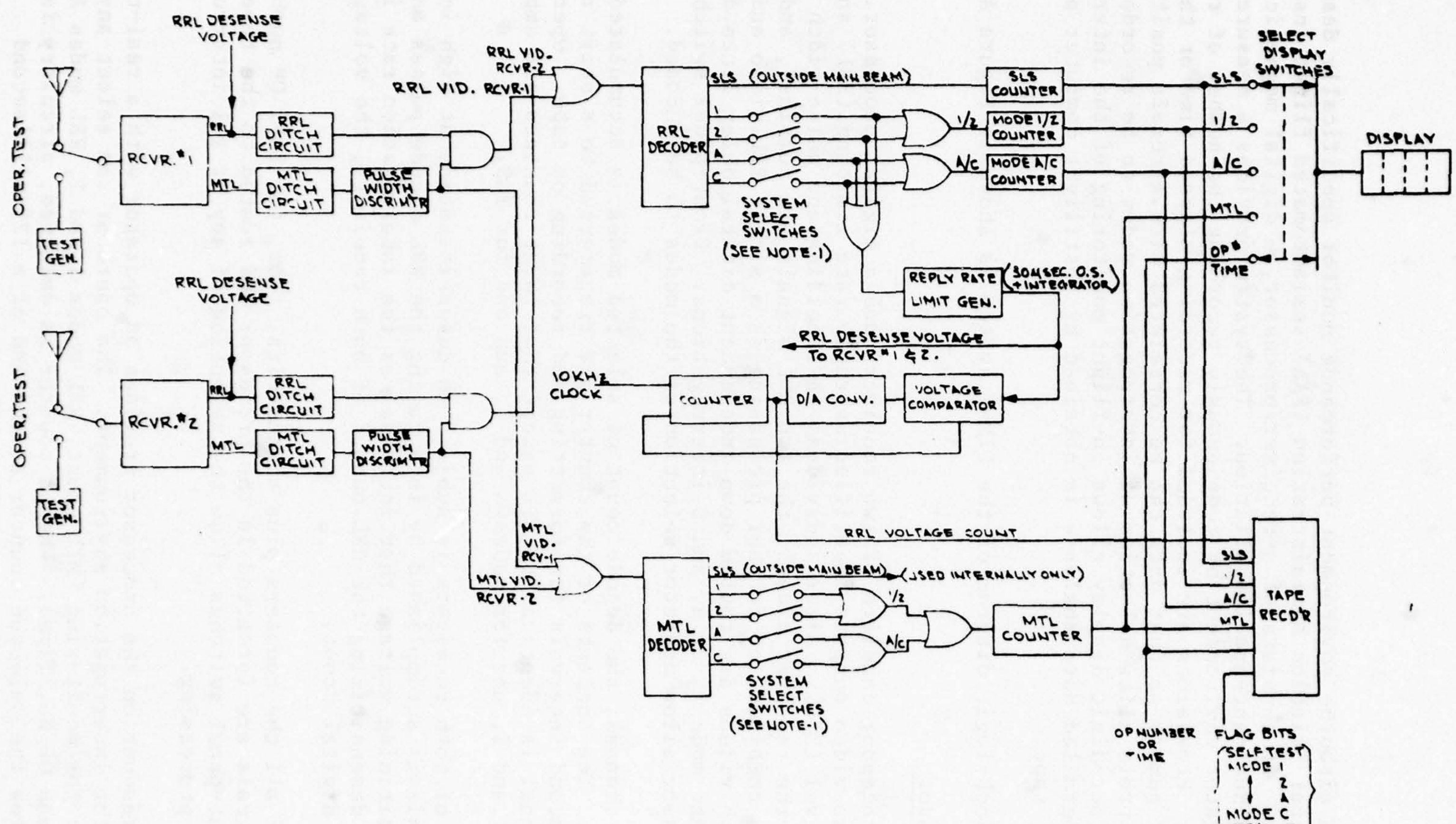
The receiver/processor consists of two receivers and a digital processor. Each receiver has two video outputs identified as reply rate limiting (RRL) and minimum trigger level (MTL). After individual thresholding and pulse-width discrimination of the receiver videos, the two RRL signals are combined, and the two MTL signals are combined for further processing as a single RRL video and single MTL video. Both videos are routed down independent digital delay lines designed to decode SLS and mode 1, 2, A, and C interrogations. Front-panel switches on the receiver/processor allow operator selection of the modes to be decoded.

Within the MTL channel, the decode count of selected modes is accumulated in a single counter. The contents of the counter are transferred to a shift register at 125-milllisecond intervals for formatting and recording on tape. Operation of the RRL channel is identical to MTL except that three counters are employed; one for modes 1 and 2, one for modes A and C, and one for SLS.

The RRL output of both receivers is subject to desensitization at high interrogation rates. This is accomplished by integrating the RRL decode pulses and producing a desensitizing voltage that increases as the interrogation rate increases. In addition to desensitizing the RRL output of both receivers, the voltage is converted to a digital count.

The contents of all the counters plus status bits, time, (or SAFI OP number), and control signals are formatted in the processor and routed to the tape recorder. Front-panel switches allow the selection of any or all interrogation modes for processing.

A front-panel readout on the processor provides an operator with a real-time indication of the interrogation environment. The operator can select any one of five signals for monitoring (MTL count, RRL modes 1 and 2, RRL modes A and C, SLS count, and OP No./Time). When a counter is selected, circuitry in the processor samples the selected counter at the end of a 125-millisecond



NOTES:

1.- Two Sets Of Select Switches Shown For Clarity., System Actually Contains Only One. When A Mode Is Selected, Both RRL & MTL Are Activated.

FIGURE A-1. FIM-I FUNCTIONAL BLOCK/LOGIC DIAGRAM

period, and displays this count on the indicators. An operator control allows this count to be displayed for an interval of from 1 to 10 seconds, at which time a new reading is generated. When OP No./Time is selected, the readout displays either the OP No. input from the SAFI equipment or elapsed time in 10-second increments depending on the position of a front-panel control switch.

Tape Recorder

A Digi-Data model 1537-556 seven-track incremental-type tape recorder is used for data collection and is an integral part of the FIM-I system. An interconnecting cable between the tape recorder and the receiver/processor allows information compiled in the receiver/processor to be digitally recorded on magnetic tape. The recorder was physically mounted directly below the receiver/processor in a standard 19-inch rack in the test aircraft.

Antennas

The FIM-I receiver input signals are supplied by two Transco 11D00800-1 L-band antennas, located fore and aft on the test aircraft. The forward antenna is mounted on top of the nose of the test aircraft, 10.5 inches aft of the radome bulkhead. The rear antenna is located 10.5 inches forward of the tail tip. Two equal lengths of RG-214 coaxial cable are used to connect the two antennas to the FIM-I receiver/processor input jacks, J3 and J4. All flight testing will be done with the forward antenna connected to receiver number 1 (J3) and the rear antenna connected to receiver 2 (J4) of the FIM-I under test. An illustration of the physical mounting of the antennas is shown in Figure A-2.

Software Development

Software for test and evaluation data analysis included the development of programs to unpack the source recording tape, provide data table listings, and provide plots which graphically show the interrogation counts received as a function of time. The reduction program is divided into two pahses, Phase 1 reads the FIM tape and creates the arrays from the input data. Phase 2 begins after the required number of samples have been read from the tape. This phase includes the list, plot, and data element average routines.

The input tape consists of consecutive samples of:

1. Mode A and C interrogation counts.

2. Mode 1 and 2 interrogation counts.

3. MTL interrogation counts.

4. SLS interrogation counts.

5. RRL voltage sample.

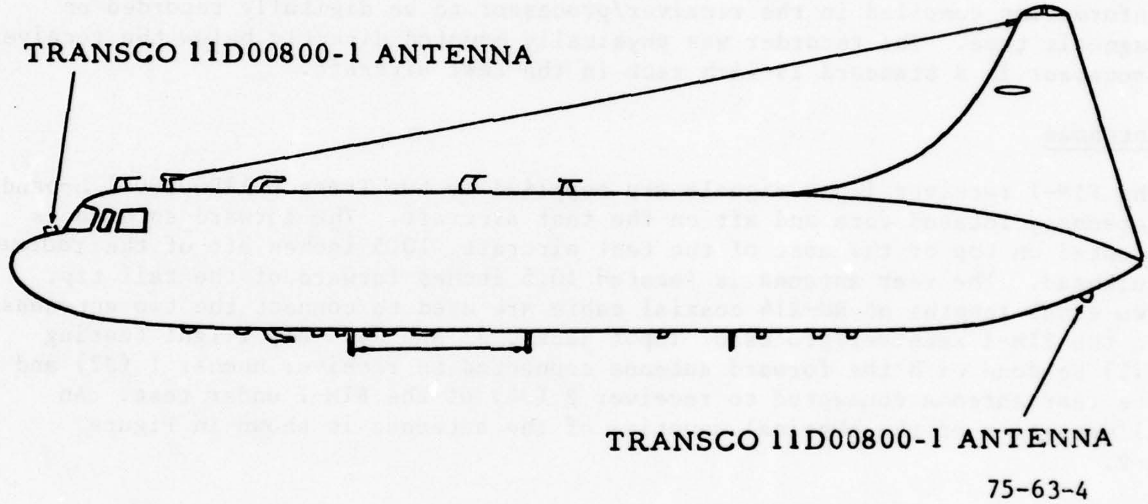


FIGURE A-2. LOCATION OF FIM-I ANTENNAS ON CONVAIR 580

A logical record contains all pertinent data for a 1/8-second period. A physical record is composed of 80 logical records. Phase 1 of the reduction program reads this tape and fills arrays with data. Each element in the array is determined from (1) a 1/8-second sample from the FIM tape; (2) eight samples (i.e., 1-second samples); or (3) 80 samples (i.e., 10-second samples).

Tape errors are noted online during Phase 1.

Phase 2 consists of plotting or listing. These operations are requested through the interactive keyboard and subsequently performed by the computer. The software development was divided into three parallel programs. These programs are identical with the exception of the way they handle the input data.

Samples from FIM are counts with 1/8-second updates. These counts are used in the following manner in the four analyses.

1. Each 1/8-second count is maintained separately.
2. Eight counts are added to provide 1-second averages of the FIM data.
3. Forty counts are averaged to provide 5-second averages of the FIM data.
4. Eighty counts are averaged to provide 10-second averages of the FIM data.

The reduction programs provides the following features:

1. Listing of the refined data.
2. Plots of the Modes A and C counters.
3. Plots of the Modes 1 and 2 counters.
4. Plots of the MTL counters.
5. Plots of the SLS counters.
6. Averages of several consecutive data elements.
7. Plots of the RRL voltage
8. Listings of the peak values for any function.
9. A summation of the SLS, A and C, and 1 and 2 counters.
10. Auto scaling or fixed scaling of the graphic plots.

Figure A-3 is a sample plot of SLS data and shows nine records (90 seconds) of the individual 1/8-second SLS counts. Figure A-4 is a listing of refined data. The values shown are averages of 80 1/8-second counts (10 seconds) which are then normalized to counts per second.

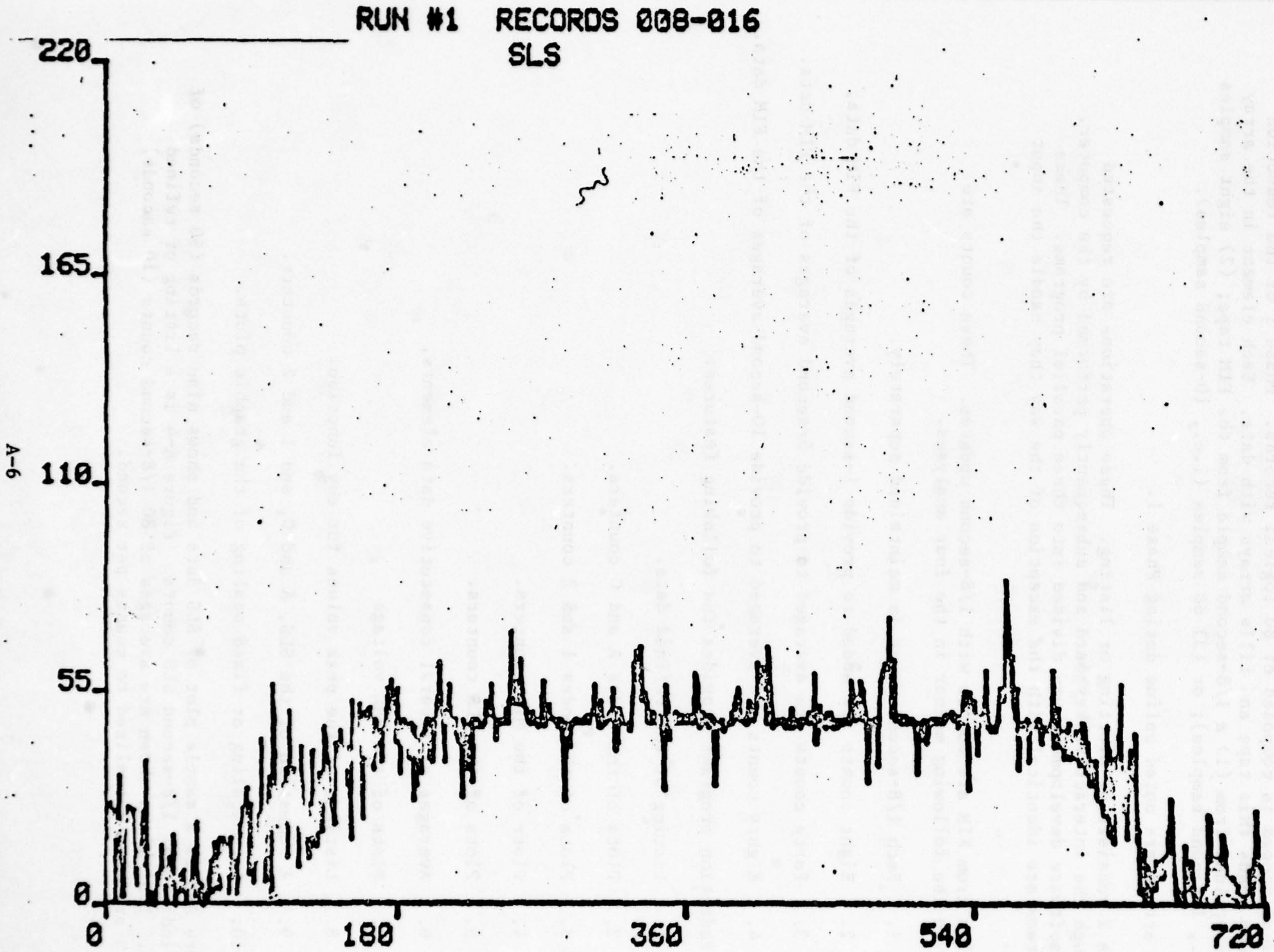


FIGURE A-3. PLOT OF FIM DATA

REC	RRL	SLS	AC	12	SUPP
1	4.0	437.4	259.4	48.8	745.6
2	4.0	286.0	324.4	21.4	631.8
3	4.0	151.4	281.8	13.8	447.0
4	4.0	338.6	271.2	24.2	634.0
5	4.0	507.0	252.2	30.2	789.4
6	4.0	544.4	253.6	30.8	828.8
7	4.0	468.0	209.0	30.0	707.0
8	4.0	268.0	205.8	24.0	497.8
9	4.0	350.0	200.8	28.4	579.2
10	4.0	236.2	212.2	11.8	460.2
11	4.0	377.4	218.2	30.8	626.4
12	4.0	254.4	203.4	15.8	473.6
13	4.0	339.8	215.2	24.6	579.6
14	4.0	327.4	211.2	16.8	555.4
15	4.0	257.2	228.4	23.4	509.0
16	4.0	306.4	179.8	17.4	503.6
17	4.0	129.4	159.6	13.8	302.8
18	4.0	150.8	111.4	12.8	275.0
19	4.0	109.8	112.8	18.0	240.6
20	4.0	62.8	150.6	14.8	228.2
21	4.0	147.6	152.8	18.4	318.8
22	4.0	102.2	98.8	10.4	211.4
23	4.0	218.0	105.6	23.0	346.6
24	4.0	89.0	92.6	11.4	193.0
25	4.0	220.4	96.4	17.0	333.8
26	4.0	97.6	82.2	11.0	190.8
27	4.0	40.6	70.2	12.4	123.2
28	4.0	133.0	73.6	11.2	217.8
29	4.0	45.8	78.8	11.4	136.0
30	4.0	86.8	53.8	9.0	149.6

FIGURE A-4. LISTING OF FIM DATA

APPENDIX B

DABS FRUIT GENERATOR

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DABS Fruit Generator - Requirements

A requirement existed for a unit which could be used to simulate the environmental impact of DABS implementation on existing ATCRBS facilities. Each DABS reply can occupy 4 to 9 miles of airspace making that time interval unusable for ATCRBS replies as DABS will render the overlaid replies unintelligible. The DABS replies to a victim ATCRBS facility will be asynchronous (fruit).

The following requirements were made for the DABS Fruit Generator.

1. The generator must be a small portable unit so that it can easily be transported to an existing ATCRBS facility.

2. It must utilize a digital approach wherever feasible.

3. It must produce a pseudo-random repetitive pattern for fruit generation.

4. It must provide a selectable DABS fruit rate.

5. It must be capable of providing overlapped DABS fruit.

6. It must output true DABS messages of both long and short duration (56 or 112 microseconds (s).

7. The selection of messages to be produced must be programmable.

8. Capability of mixing DABS fruit with incoming ATCRBS replies must be provided.

Description of Equipment

The DABS Fruit Generator was developed and fabricated at NAFEC. It consists of a small card cage with self-contained power supplies. It requires no external inputs, but will accept external triggers and video if desired. All inputs and outputs are via coaxial connectors. The system block diagram is shown in Figure B-1.

The system is controlled by a 2 megahertz (MHz) crystal derived clock source. The system contains two independent fruit generators whose outputs are combined. Each fruit generator is controlled by a pseudo-random number generator which is clocked at a 250 kilohertz (KHz) rate. The two number generators have the same period but are started at different times by the power up (PUP1 and PUP2) signals. For each cycle of the number generators (42 seconds) the clock to number generator 2 is shifted by 500 nanoseconds (ns) with respect to generator 1.

Each fruit generator contains switches which control its contribution to the overall output. The outputs of both fruit generators are combined with externally applied ATCRBS data in a line driver which can then be used as the video input of a system to be tested.

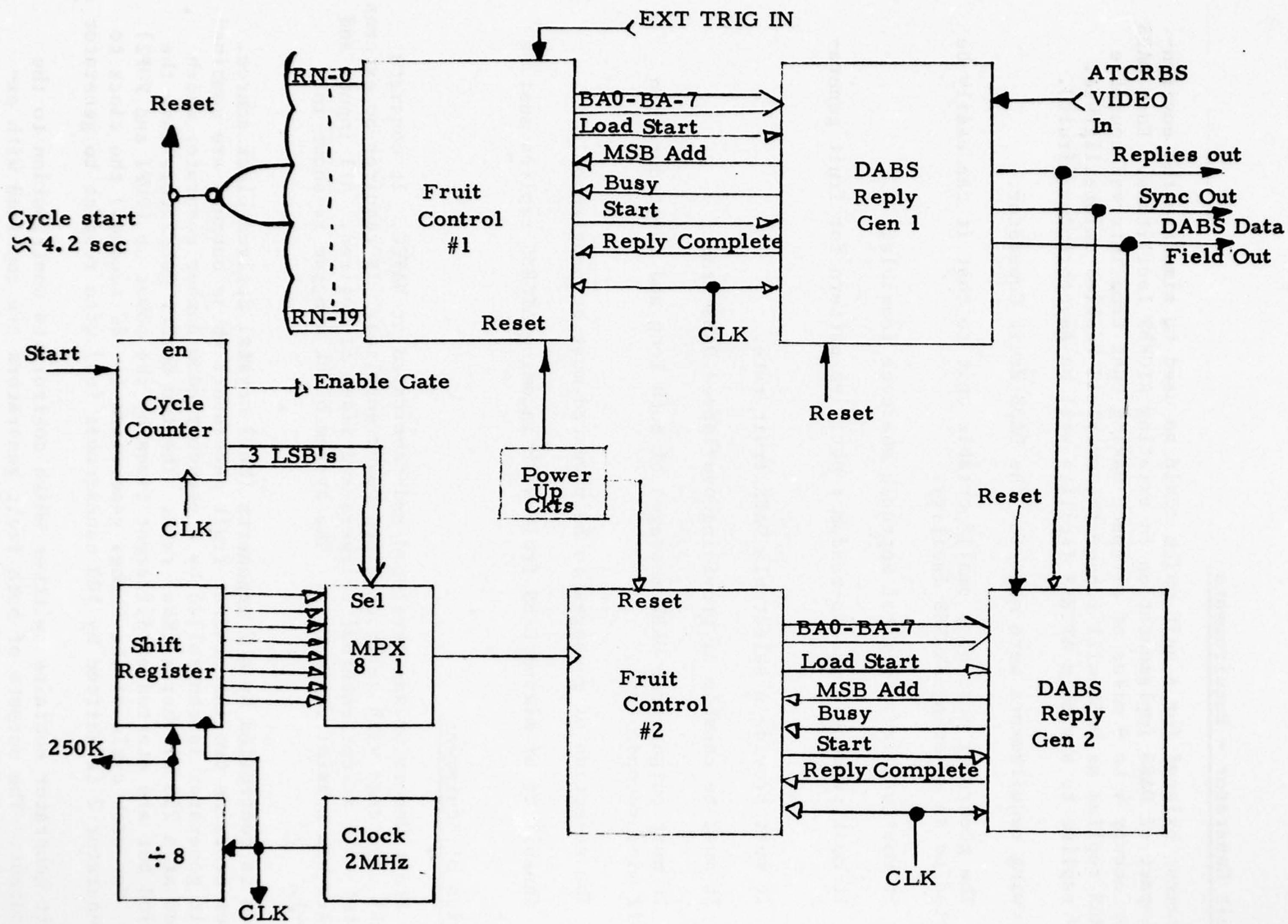

FIGURE B-1. DABS FRUIT GENERATOR BLOCK DIAGRAM

One of the fruit generators can also be triggered externally so that a ring target can be generated if desired.

Also included is a cycle counter control signal which can provide a gate to external equipment of up to 256 cycles of the number generator.

DABS Reply Generator

A block diagram of the DABS reply generator is shown on Figure B-2. The message content of each DABS reply is stored in a programmable read-only memory (PROM). The DABS reply output is a serial data stream of either 56 or 112 μs in duration, which is prefixed by a "preamble" whose first pulse occurs 8 μs prior to the first data pulse position.

This sequence is generated by loading a 16 bit shift register with either the preamble pattern or data from the PROM and shifting it out at a 2 MHz rate. The PROM addresses are selected by the fruit control card. The "start" and "stop" addresses of the next message to be generated are loaded into the address counter and stop address latch. When the signal is received to start generating a reply the control logic selects the preamble pattern via the shift register input multiplexer, loads the shift register and begins to shift out this data at a 2 MHz rate. Each 8 μs a new set of data is loaded from the PROM to the shift register and the PROM address counter is incremented. When the stop address is reached, a signal is sent to the fruit control card to notify it of task completion. The present PROM contains 14 different 56 bit messages. All are realistic messages and contain correct address/parity fields when applicable.

DABS Fruit Control

A block diagram of the fruit control card is shown on Figure B-3.

The DABS fruit control card contains a 20 bit pseudo-random number generator. It is comprised of a shift register with feedback applied so that the output bit pattern will repeat every 4.2 seconds. Twelve outputs of the number generator are compared to the fruit rate select switches. When the value of the select switches is less than that of the number generator, the comparator output goes high enabling a programmable eight bit counter.

When a carry is produced by this counter and the reply generator is not busy the start signal is issued and a DABS reply is generated. Each carry also presets the counter to a new value (the four least significant bits are from the number generator and the four most significant bits are from the fruit rate select switches).

DABS replies can be selected in increments of approximately four replies per second. The timimg distribution of the replies can also be changed by the use of the switch controlling the most significant bits of the programmable counter.

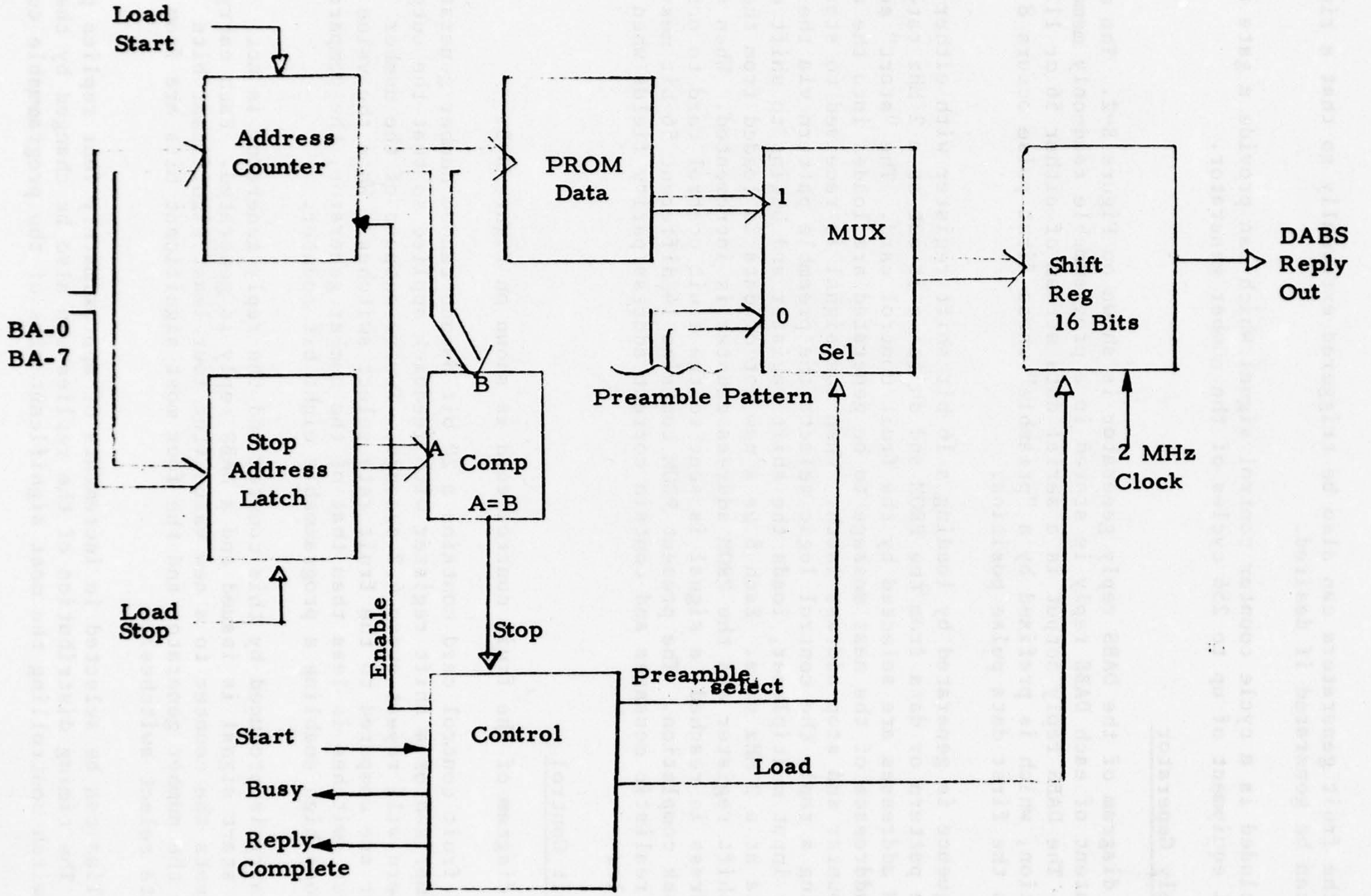

FIGURE B-2. BLOCK DIAGRAM DABS REPLY GENERATOR

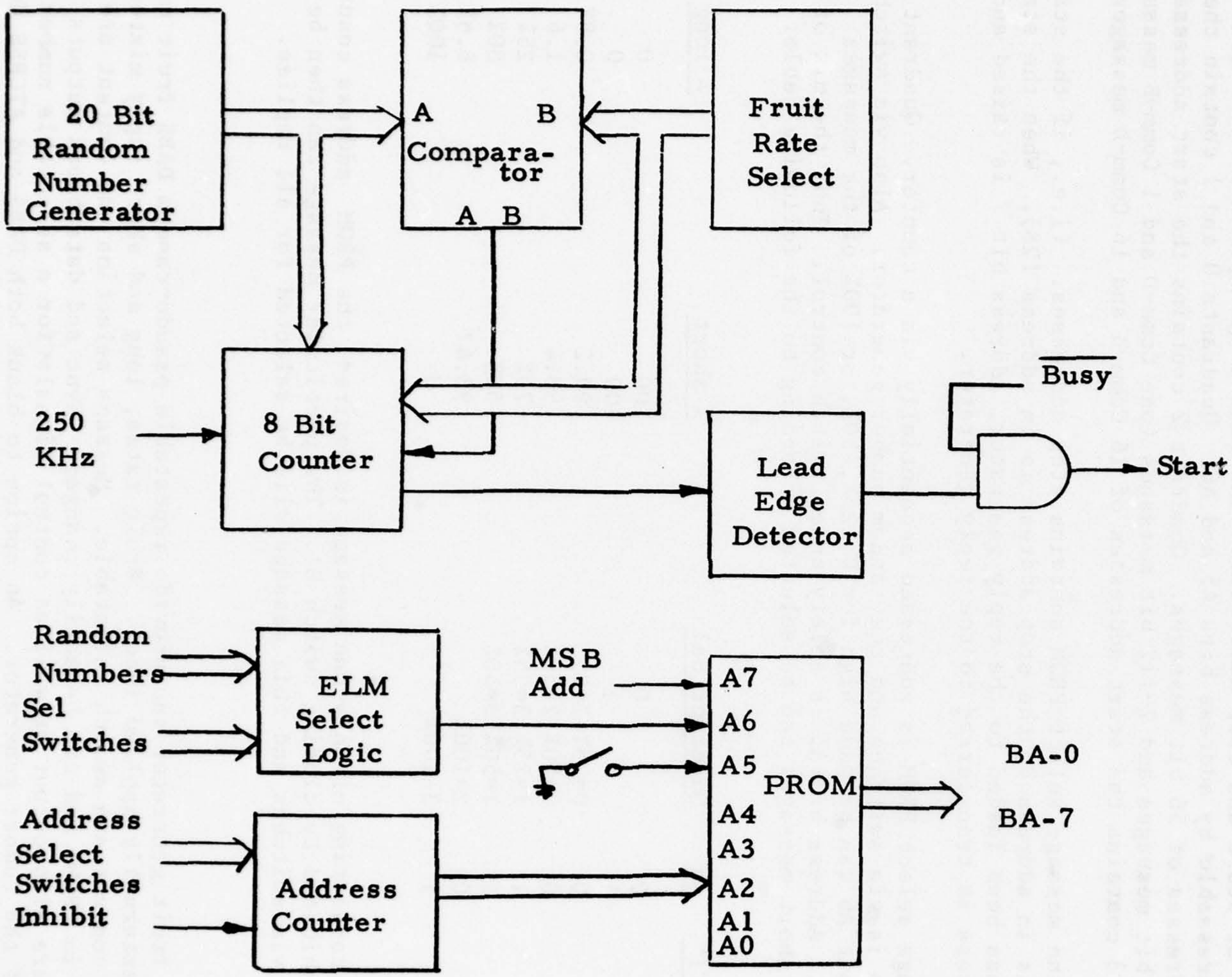

FIGURE B-3. FRUIT CONTROL BLOCK DIAGRAM

The fruit control card also contains a PROM which controls the selection of DABS messages in the data prom on the reply generator. This PROM contains 128 pairs of start and stop addresses. The data is grouped into four quadrants addressable by address bits A5 and A6. Quadrants 0 and 1 contain the start addresses of 56 bit messages. Quadrant 2 contains the start addresses of 30-56 bit messages and 2-112 bit messages (one Comm-D and 1 Comm-B message). Quadrant 3 contains the start addresses of 16 Comm-B and 16 Comm-D messages.

Half of the message select PROM contains stop addresses. (i.e., if the start address is in address 0, the stop address is in address 128). When the start address has been loaded to the reply generator, address bit 7 is raised and the stop address is transferred to the reply generator.

The message select PROM is addressed sequentially via a counter. Quadrant selection is via switches and the random number generator. Also via switches, address bit A6 can be made high for 0, 25%, 50%, or 100% of the messages selected. Address bit A5 is solely under switch control. Thus the mix of long and short messages can be selected according to the following table:

% of A6="1"	A5	Quadrant Sel	% short	% long
0	0	0	100	0
0	1	1	100	0
25%	0	0=75% 2=25	99.2	0.8%
50%	0	0=50% 2=50%	98.4	1.6
25%	1	1=75% 3=25%	75%	25%
50%	1	1=50% 3=50%	50%	50%
100%	0	2=100%	93.47	6.6%
100%	1	3=100%	0	100%

If fruit consisting of only one message is desired, the PROM address counter can be inhibited by closing switch S1. The particular message can then be selected via switches and this message will be selected for all replies.

SUMMARY

The DABS fruit generator can provide repeatable pseudo-random DABS fruit mixed with an externally applied input. Fruit rates, long and short reply mixture and data content are switch selectable. Message selection and content are resident in PROMs and can be easily changed. Sync and data block outputs signals are also output as well as control signals for a selectable number of cycles of the number generator. An option to blank both DABS and ATCRBS during the data block of the DABS replies was also provided.

Typical Message Set

Table B-1 contains a typical message set used during testing. It shows the different DABS messages and the approximate contribution of each to the overall DABS Fruit. Although the fruit rate was varied, the mixture of message contribution remained constant.

TABLE B-1

DABS MESSAGE	% CONTRIBUTION
1. C54129854576AA	4.7
2. DZB76C93B7071F	4.7
3. D194F767E6ZE5A	4.7
4. C94EAA98114897	2.3
5. C62844CC6D1FF3	2.3
6. C94E96AE868BDB	2.3
7. 00063A0920BF6F	9.4
8. 04031B748EDDAZ	11.7
9. CABC0621F88EC6	9.4
10. 008706C3ACD74F	4.7
11. D64987A68526F3	4.7
12. 4A1C9AF54D16D7	4.7
13. 8C18FF3562E07F	4.7
14. A74EAA9878AD9C	4.7
15. 40C4482690626C22862C89F70DC7	4.7
16. 447B83FFD507434C318BD8AB60A0	4.7
17. CC89CA44AE84296AE694EC086484	3.1
18. F3293657010488042957156F037E	3.1
19. F3194316446364904621 32C2DA69	4.7
20. F3284117738394902997 76A43006	4.7

APPENDIX C

ATCRBS TARGET/FRUIT GENERATOR

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General Description

The ATCRBS Target/Fruit Generator was developed to provide a repeatable ATCRBS reply source designed to be used in testing an ATCRBS processor. It was designed to produce ATCRBS replies that simulated the live environment in as many areas as feasible.

Data was extracted from the Sensor Receiver and Processor (SRAP) and Beacon Data Acquisition Subsystem (BDAS) using "live" inputs. Run length and hit count distributions were generated which characterized the live inputs. The data required for the target generator to reproduce these distributions was burned into PROMs. Extractions were then made, using the generator as the SRAP and BDAS inputs in order to verify the simulation of the live environment.

A wide selection of variable parameters were incorporated so that the system was flexible enough to satisfy the requirements of the various systems encountered.

Figure C-1 is an overall block diagram of the ATCRBS Target/Fruit Generator. All system functions are tied to an eight bit data bus (DAT-0....DAT-7) via which all controls are exercised. All system parameters (except system status) can be entered automatically via self contained PROMs or via keyboard. The PROMs can contain several sets of "canned" parameters if desired.

The system contains three identical code generators whose outputs are combined in the input/output (I/O) control section.

A list of selectable parameters is given below:

A. Code Generator

1. Input trigger of each code generator is selectable via keyboard from an internal, external, or fruit generator source.

2. Each code generator is capable of four different codes during a test run. The codes can be selected to be "mode sensitive" (i.e., 2 for Mode A and 2 for Mode C).

B. Number of Targets

1. The number of targets can be controlled externally by selecting external triggers and azimuth gates to control the code generators.

2. When using internal triggers to generate codes, the number of rings of targets is selectable.

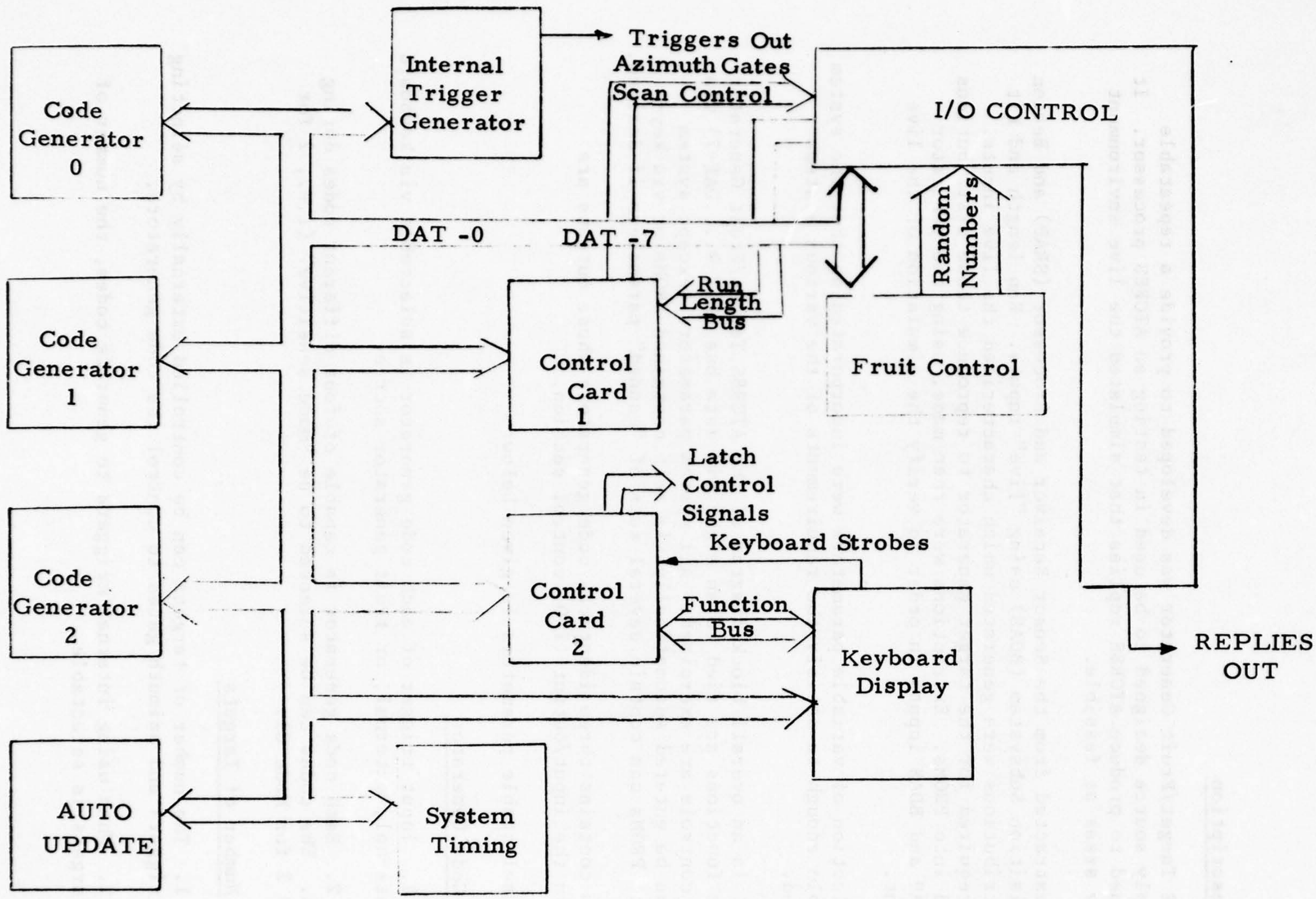


FIGURE C-1. BLOCK DIAGRAM ATCRBS REPLY GENERATOR

3. The number of targets in azimuth can also be selected to be 1, 2, 4, 8, 16, or 32 as decoded from the azimuth counter.

4. The azimuth of adjacent rings of targets can be offset by an amount up to 128 azimuth change pulses (ACPs)

C. Target Run Length

1. The target run length is controlled in ACPs and can vary between 2 and 128.

2. Run length selection has 2 modes:

a. Fixed - All targets have the same run length and can be controlled from the keyboard or PROM.

b. Random - Target run length selection is under the control of the random number generator which addresses a PROM containing run length data.

D. Round Reliability

The round reliability function also has 2 modes:

1. Round Reliability = 1, in which all targets have a round reliability of 1.

2. Random Round Reliability - The round reliability decision is based on a round reliability PROM for the code generators which are generating targets. If a code generator is being used to generate fruit, its round reliabiity is automatically equal to 1.

E. Fruit Rate

The fruit rate is selectable in increments of 20 fruit replies per second up to 40,000 per second. This selection is accomplished via keyboard or PROM and can be automatically updated during the off scans when in the auto-update mode.

F. Scan Control

The output video can be gated on or off under the control of a scan counter as follows: Video on for N_1 (1 to 256) scans followed by video off for N_2 (1 to 256) scans with the sequence repeated up to 16 times.

At the beginning of the series of "off" scans, the scan control logic enables the auto-update logic.

At the beginning of the series of "on" scans, the scan control logic reinitializes the random number generators.

G. Auto Update

The function(s) to be updated automatically can be selected via PROM only. The update values must also be stored in the PROM. This function is normally used to update the fruit rate, but any function (except status) can be updated automatically.

H. Azimuth Rate

When generating internal azimuth data, the rate is selectable from below 1 second per scan to approximately 13.5 seconds per scan. The output drivers are capable of driving a 50 ohm impedance.

I. Internal Triggers

Generation of internal triggers is controllable via a PROM. The system is capable of either fixed or staggered PRF generation and any mode interlace desired. The number of pulses per PRF along with their spacing and widths are also variable.

The following section will discuss each functional module at the block diagram level.

System Timing

Figure C-2 is a block diagram of the system timing card. The master clock source is a 20 MHz crystal controlled oscillator. All other system timing signals are derived from this clock and all are aligned with it before distribution to the system. Most of the system modules use the 10 MHz clock.The code generators, however, require a 20 MHz source in order to provide nominally spaced code pulses. The 333.3 KHz and 327.9 KHz clocks (20 MHz ÷ 60 and 61, respectively) are used by the two fruit generators.

The system timing card also contains the control logic for azimuth data selection. The ACP and ARP jacks function as both input and output sources. For this reason, when power is applied, the system always comes up selecting external inputs in order to avoid damage to either the drivers of this system or another systems driver, if both are supplying azimuth data. A status word entry then allows the system to generate azimuth data if desired. The rate is controllable either via the keyboard or from a system PROM load. Scan rates are selectable from well below 1 scan per second to approximately 13.5 seconds per scan in increments of 50 milliseconds (ms) per scan.

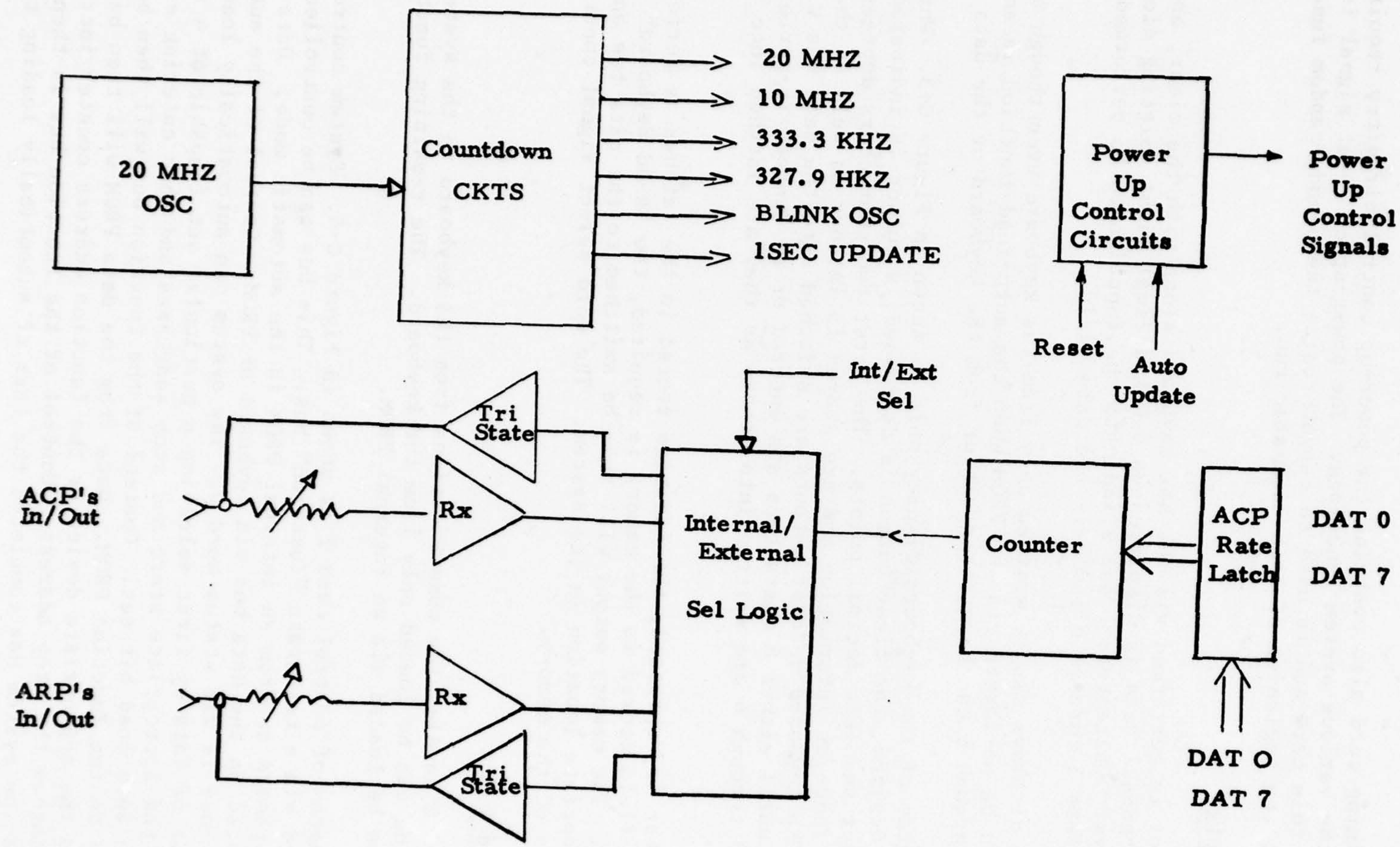


FIGURE C-2. BLOCK DIAGRAM SYSTEM TIMING

The system timing card also contains the power-up control circuitry required to initiate the various system functions. The power-up or reset signal is also generated on this card and is used to resynchronize the pseudo-random function generators at the beginning of each automatic run.

Keyboard/Display

System control is performed via the hex keyboard along with the clear, enter and reset buttons. Data is displayed on 6 hexidecimal light emitting diode (LED) displays. Characters 1 and 2 indicate the function to be performed while characters 3 through 6 indicate the data field.

The function displays can be written only from the keyboard even though all the functions can be performed via the PROM when the auto-load function is entered. Displays 3 through 6 can be written either from the keyboard or the data bus.

A block diagram of the keyboard/display unit is shown in Figure C-3. When a function is desired, the clear button is depressed, a cursor is indicated by blinking right and left decimal points. The first two characters depressed contain the function information and are stored in latches as well as the displays. The keyboard decoder outputs are switched onto the data bus via the multiplexer until either 6 characters are entered or an "enter" is performed. Characters 3 through 6 are written into memory as they are latched into the displays.

When the enter is depressed, the function stored in the latches is performed. If the data field stored in the memory is required, the "Read Keyboard" signal is received. The memory output will then be switched to the data bus and stored in the appropriate location in the system. The word select signal controls the read address of the memory.

Control Card 2

Control card 2 handles the communications from the keyboard to the system. System status can be loaded only from the keyboard. The remaining functions, however, can be loaded via an internal PROM.

A block diagram of control card 2 is shown in Figure C-4. System control is exercised via a tri-state "function" bus. This bus can be controlled from the keyboard or from an internal PROM in the automatic mode. Data can also be placed on the data bus via keyboard or PROM. Control of the automatic load mode is via status word 0. The system can automatically load with a canned set of data by first selecting a particular set (capable of 4 sets), by loading the appropriate start and stop addresses and then entering status word 0 with auto-load bit set. Control of the function bus will then be transferred to the function PROM. Data from the data PROM will then be loaded into the appropriate device as the function address counter increments until it reaches the stop address. Control of the function bus is then released as the system has completed the task of automtically loading the

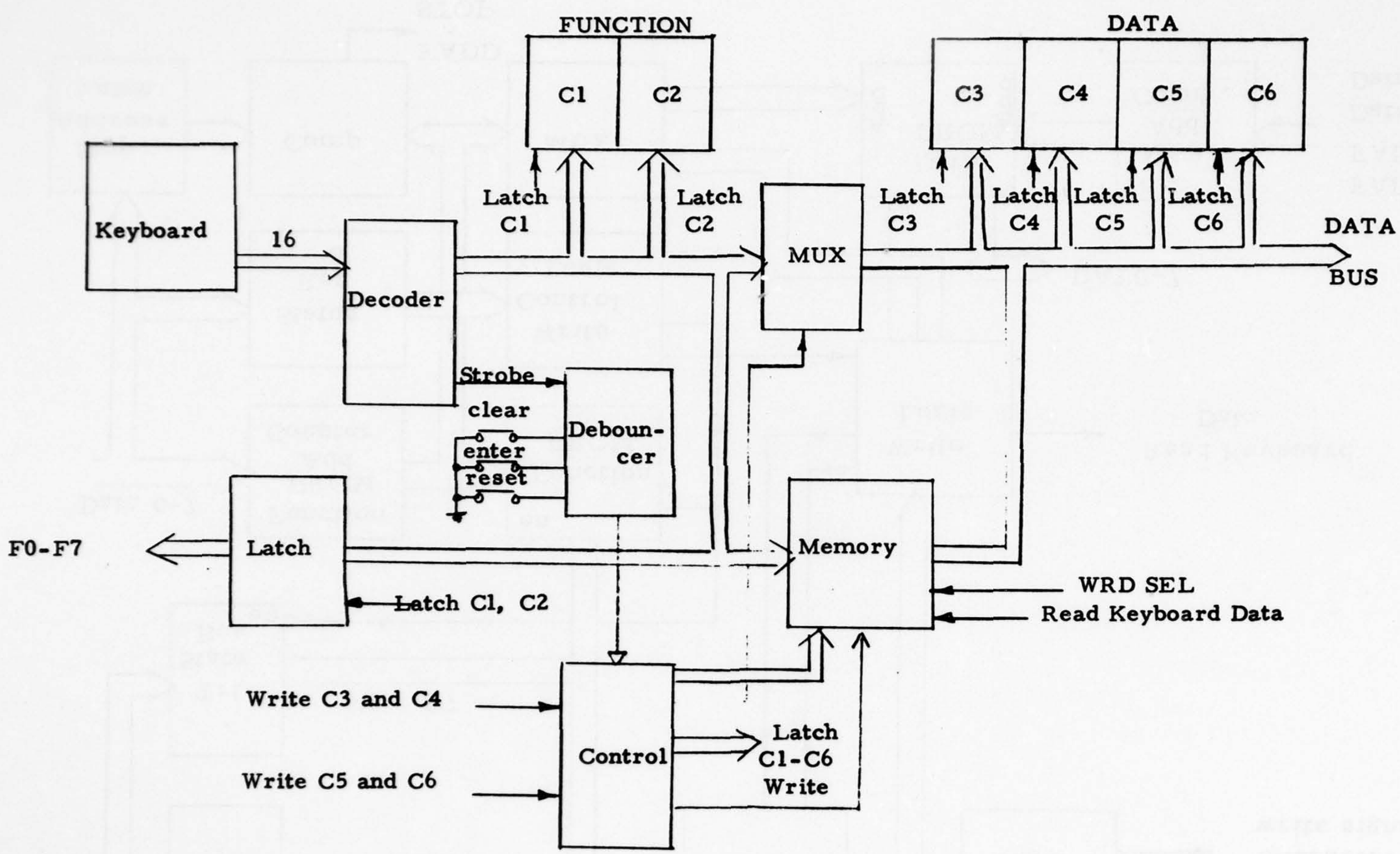


FIGURE C-3. KEYBOARD/DISPLAY BLOCK DIAGRAM

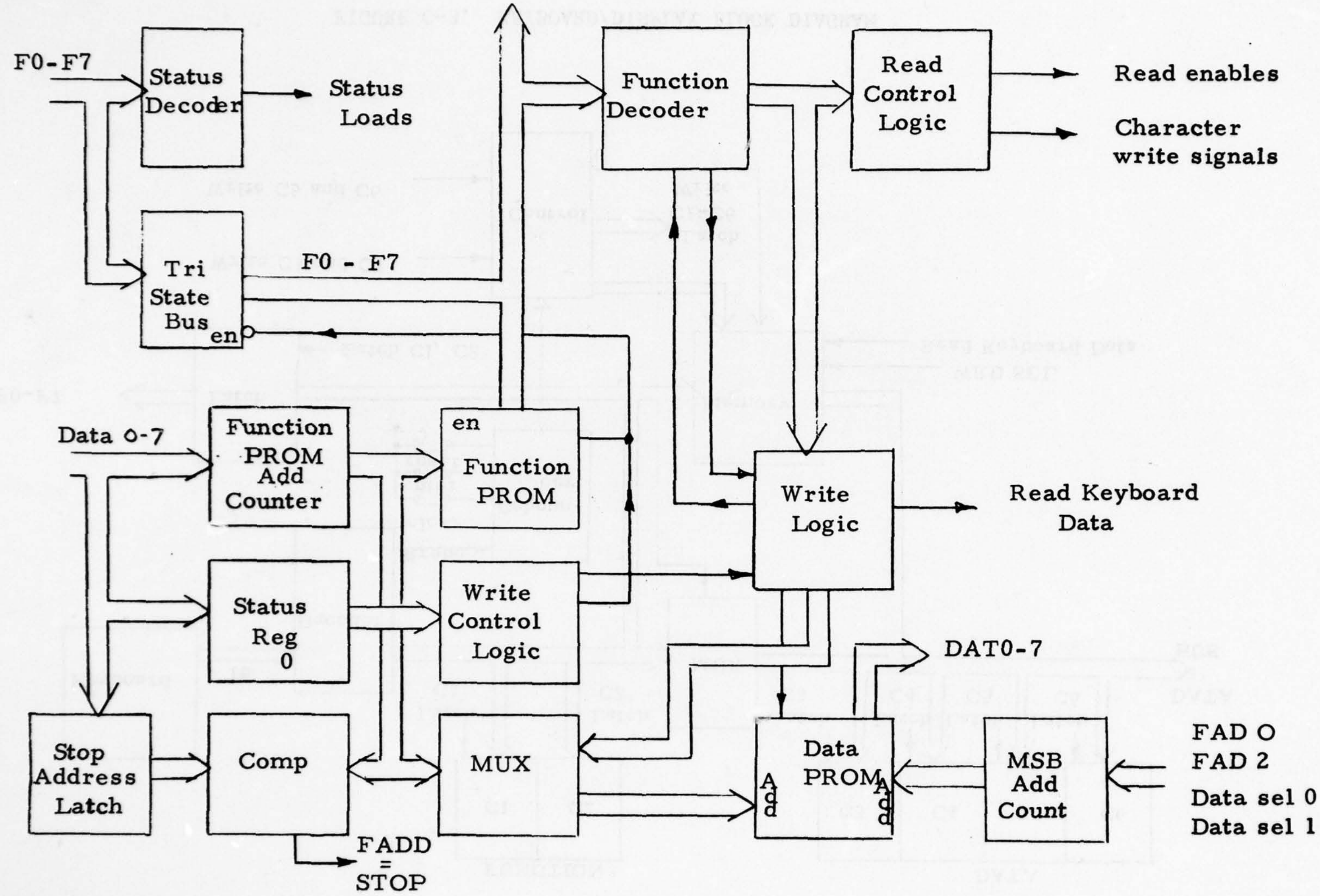


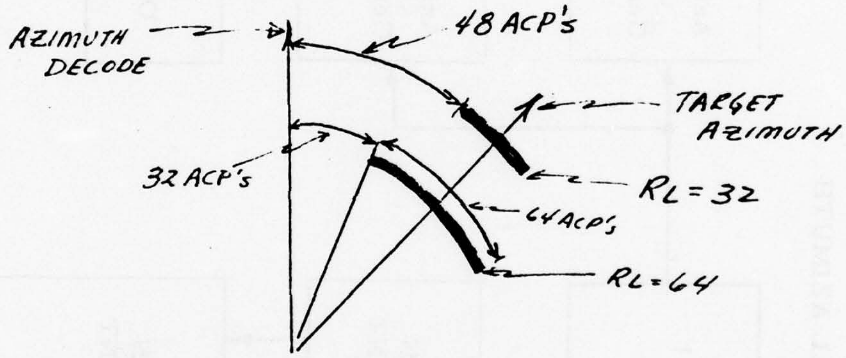
FIGURE C-4 CONTROL CARD 2 BLOCK DIAGRAM

canned data. Control card 2 also contains the read logic. Contents of the scan counter, fruit counter, and the code generators can be displayed via the 4 hex displays. The selected data is strobed to the displays once per second via the data bus when a read function is entered.

Control Card 1

A simplified block diagram of control card 1 is shown in Figure C-5. It contains the azimuth counter, scan control counter and azimuth gating circuitry for the system.

The internally selectable azimuth positions of the targets are the 7 most significant bits of the azimuth counter. The eighth choice is an external azimuth gate. The center azimuth of the target is a constant regardlsss of its runlength as indicated below:



Run lengths are in ACPs and selectable up to 128 ACPs. The run length values come from the I/O control card. Whatever run length value is present on the run length bus at the azimuth decode time will be used for that particular target. Thus the run lengths produced are completely under the control of the I/O card. The second target on a sweep can be offset from the first by a fixed azimuth. The run length control counters which produce the azimuth enable gates are merely delayed by the azimuth offset value (in ACP's). Thus the run length of the second target can also be made different from the first as the run length counters are loaded at a different time.

When scan control of the output is enabled, the scan control logic can be set to a desired sequence as follows:

1. N_1 (1 to 255) = number of scans for data ON
2. N_2 (1 to 255) = number of scans for data OFF
3. N_3 (1-15) = number of cycles of 1 and 2 above.

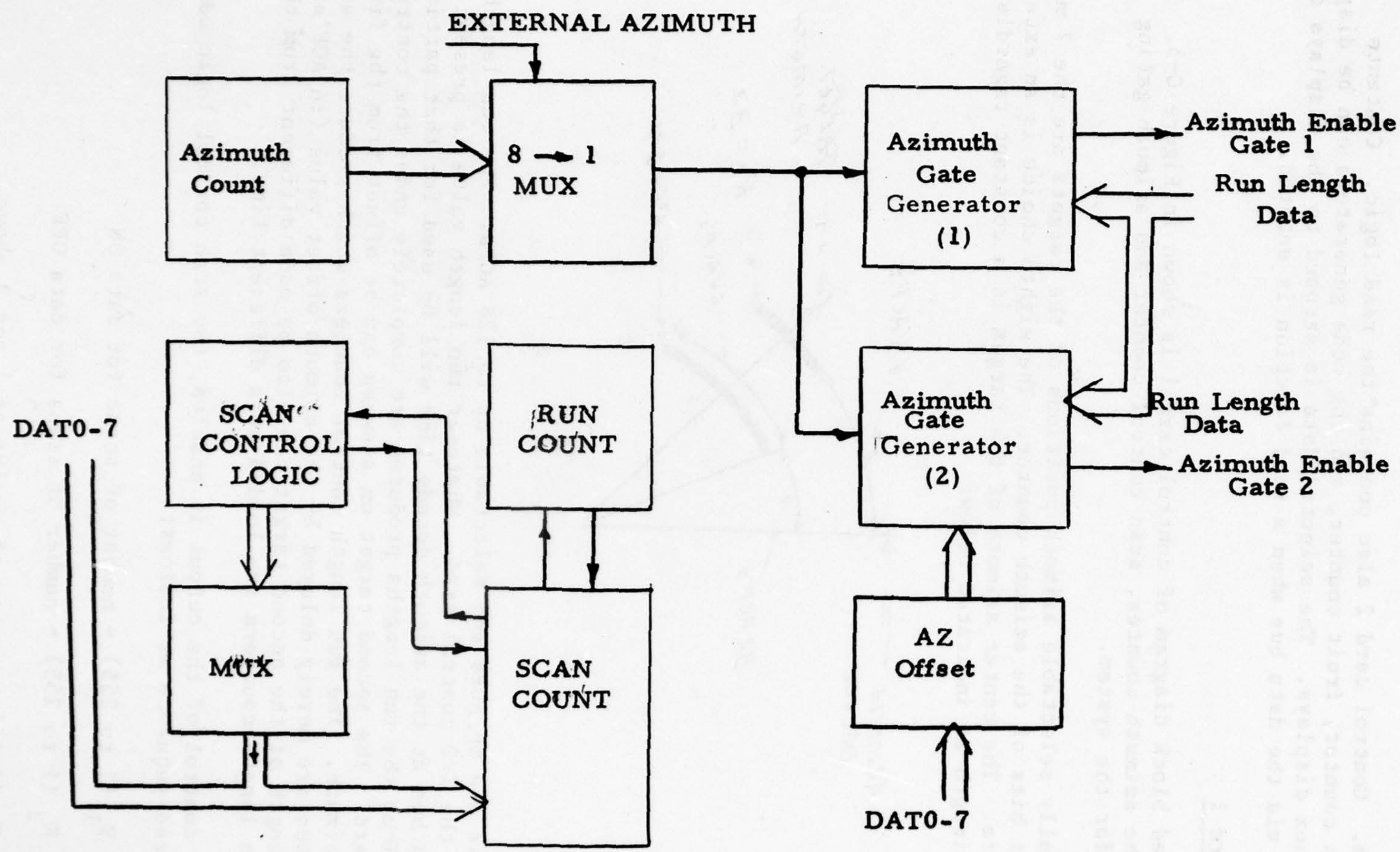


FIGURE C-5. CONTROL CARD 1 BLOCK DATA

These numbers can be loaded via the PROM or from the keyboard and are enabled by a status word entry. The scan counter can be selected for display via a read function so that the progress of a test can be monitored if desired.

I/O Control

A block diagram of the I/O control card is shown in Figure C-6. External target triggers and beacon mode triggers are received from an external source. The mode triggers are decoded and a signal is furnished to the code generators on Mode C sweeps for their use in code selection. Each code generator's input trigger is selectable via a status word. A 2-bit field is assigned to each code generator as follows:

00 = OFF
01 = External trigger
10 = Fruit*
11 = Internal trigger

*On code generator 2, this is decoded as a multiple target ring command. The number of rings is selectable via the keyboard (or PROM). In this mode, both azimuth enable gates are used so that different run lengths and round reliabilities are possible.

The round reliability information is burned into a 512x8 PROM. Nine-bits from the random number generator are used as the round reliability PROM address. Three additional random number bits are used to select one of the eight PROM data bits as the round reliability control bit for a particular target. If the bit is a "1" when the command to generate a reply is issued, the reply is allowed out. If the bit is a "0," the reply is gated off by the output control circuits.

The run length PROM is also addressed by a 9-bit random number. The PROM output and the data bus are fed to a latch which can select either the PROM value or a fixed value via the data bus. This value is then passed to control card 1 for generation of the azimuth enable gate.

All output gating is performed on the I/O control card. An overall input is the scan gate control so that all data can be gated off under control of the scan counter. The outputs of the three code generators are or'ed together providing the capability of overlapping replies.

Code Generators

The test set contains three identical ATCRBS code generators. Each produces replies at the command of the test set control logic. A block diagram of a single code generator and the code generator common logic is shown in Figure C-7.

Each code generator can produce up to four different codes during any run. The code data is stored in a random access memory (RAM) in each code generator. This data is normally obtained from a PROM which contains canned sets of data for use during a run. Codes can also be changed via the keyboard if desired. Each code requires a block of the RAM consisting of four words of 4 bits each.

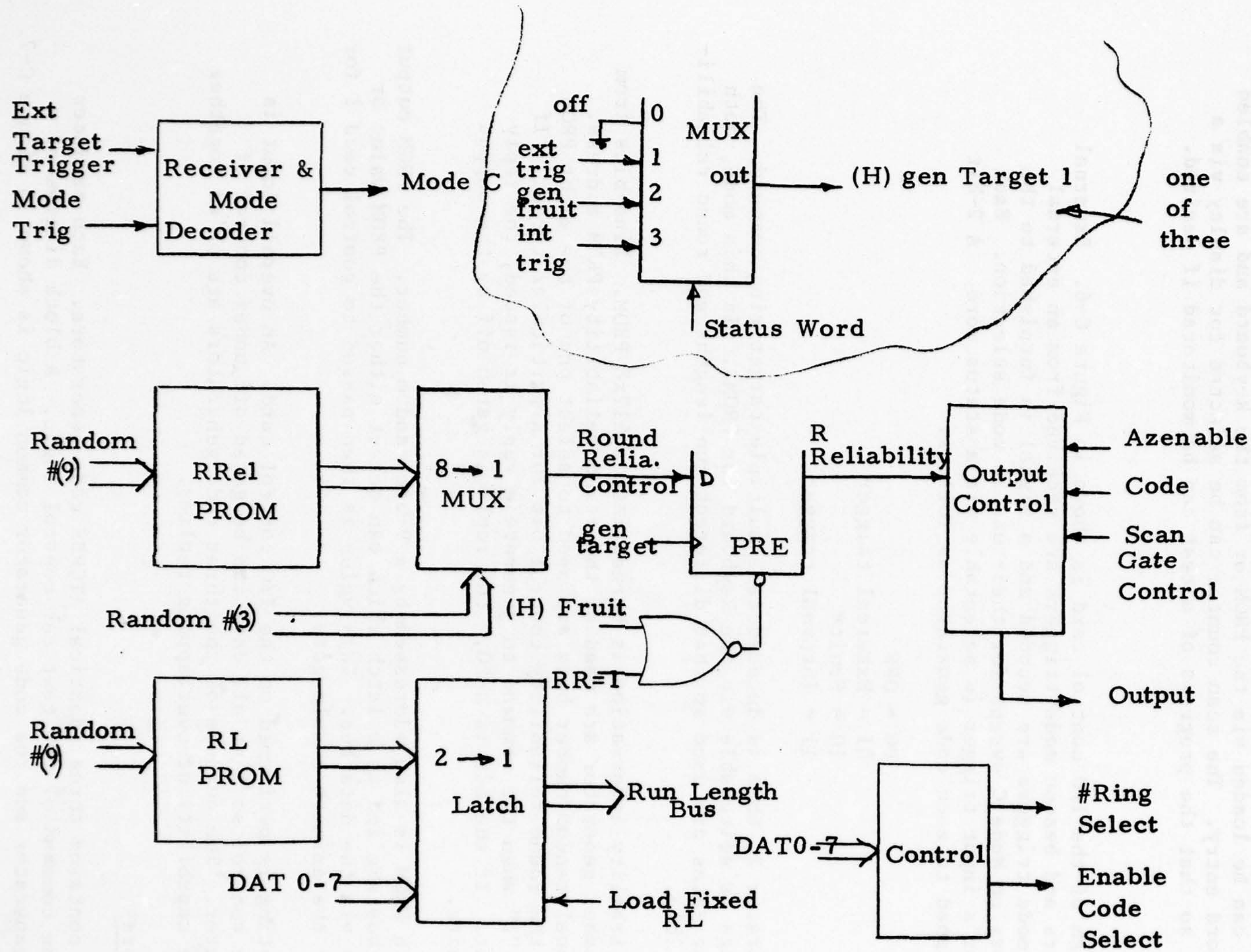


FIGURE C-6. I/O CONTROL BLOCK DIAGRAM

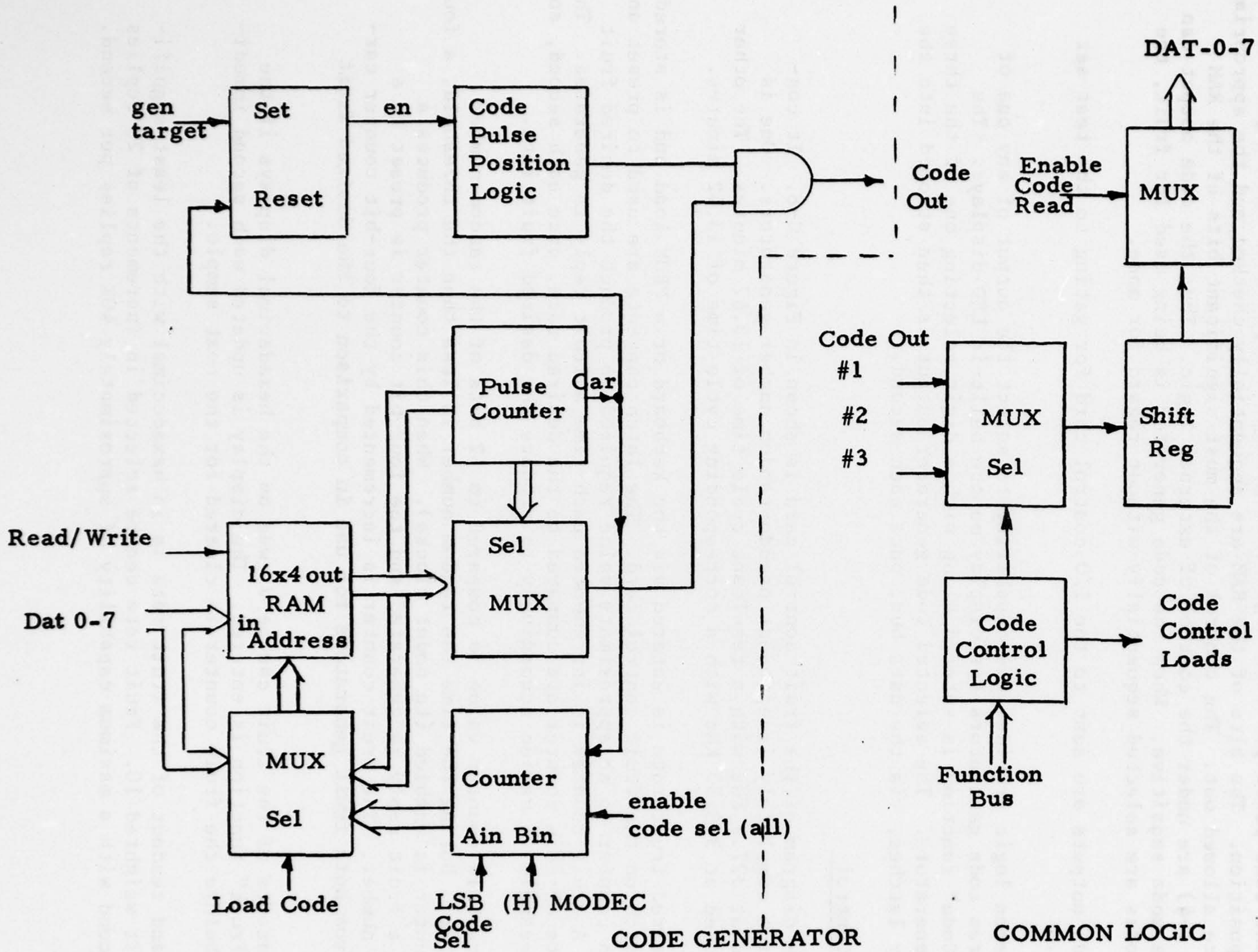


FIGURE C-7. CODE GENERATOR AND COMMON LOGIC BLOCK DIAGRAM

Then a command is received to generate a reply, the reply control flip-flop is set. The code pulse position logic then generates a pulse at each legal code pulse position. The bits of the RAM are sequentially checked and the appropriate ones are allowed out. The control of the most significant bits of the RAM (codes 1-4) are under the control of external logic. Thus the code output can be made mode sensitive. When the code generator is being used for fruit, the four codes are selected sequentially without regard for mode.

The code outputs are sent to the I/O control card for gating to the test set output.

The common logic provides the capability to select the output of any one of the three code generators for display on the built-in LED displays. The "Read Code" function is entered along with a digit selecting one of the three code generators. The selected code generator output is then strobed into the display latches, via the data bus, once each second.

Fruit Control

A block diagram of the fruit control card is shown in Figure C-8. It contains two completely independent pseudo-random number generators. One is clocked at 327.9 KHz with a resultant cycle time of 13.67 minutes. The other is clocked at 333.33 KHz with a corresponding cycle time of 13.42 minutes.

The desired fruit rate is entered via the keyboard or a PROM load and is stored in a latch on the fruit control card. The latch contents are used to preset an up/down counter to an approximate value required to produce the desired fruit rate. A fruit counter is incremented each time a fruit reply is generated. The contents of this counter are compared to the desired rate, once each second, and the threshold is varied accordingly to produce the desired fruit rate.

The threshold counter value is compared to 12 bits of the random number generator. During the time the random number is less than the threshold, a four-bit counter is enabled (to count clocks). When this counter produces a carry, a fruit reply is generated and the four-bit counter is preset to a random number. The fruit counter is incremented by the four-bit counter carries from both fruit generators for use in comparison to the desired fruit rate.

The contents of the fruit can be viewed on the hexadecimal displays if the "read fruit" function is entered. The display is updated each second immediately before the fruit counter is cleared for the next sample.

Entry and readout of the fruit rate is in hexadecimal with the least significant bit weighted 10. Fruit rate can be selected in increments of 20 replies per second with a maximum capability of approximately 40K replies per second.

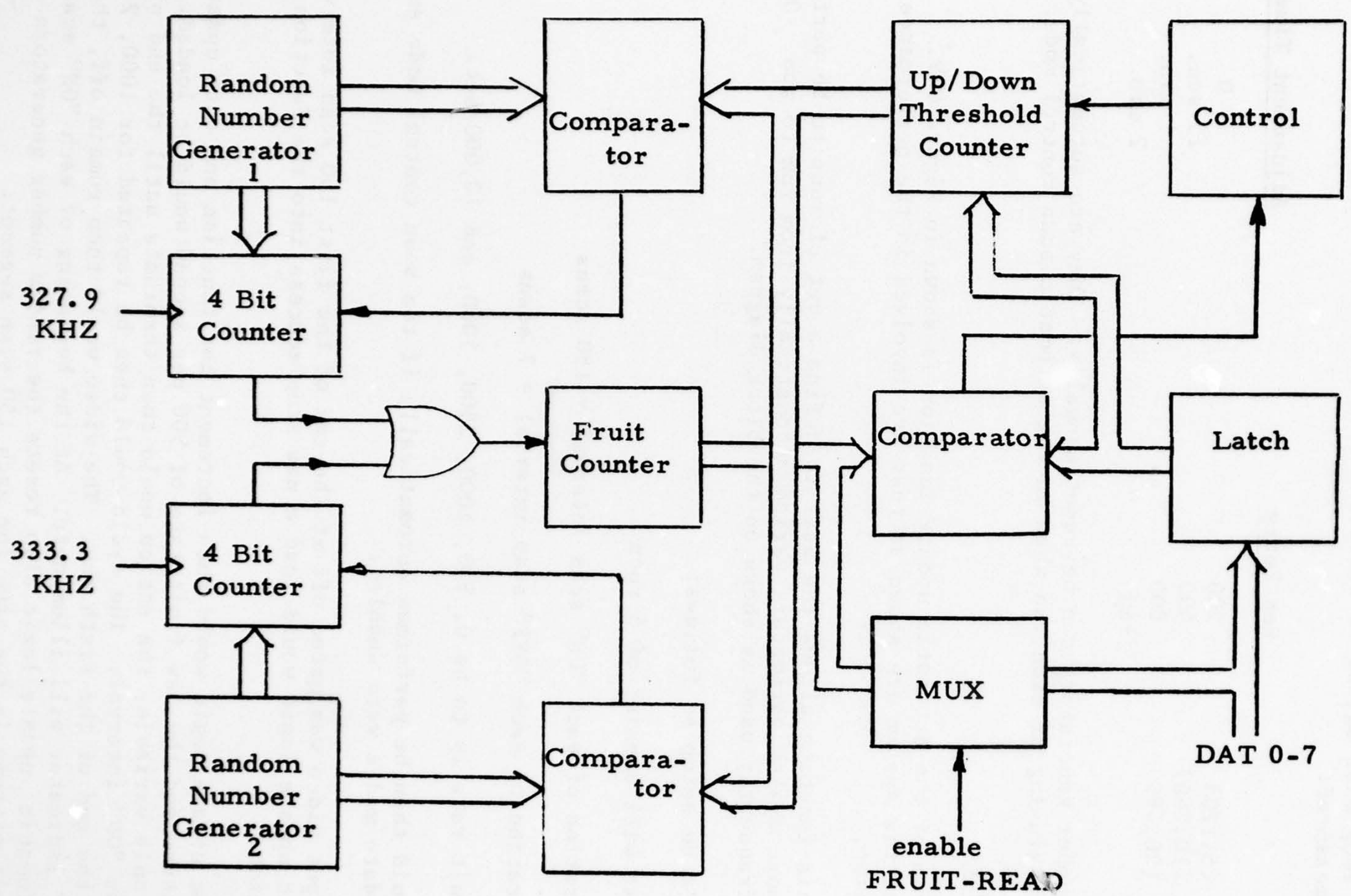


FIGURE C-8. FRUIT CONTROL BLOCK DIAGRAM

At the higher fruit rates, the four random number bits, which preset the four-bit counters, do not all have a 50% probability of being set when a carry" is produced. Thus the preset value (of the threshold counter) is in error and the loop must adjust to achieve the desired fruit rate. The following results were measured:

Fruit Rates	Hex Entry	Adjustment Time
Below 5K/sec. (5,120)	200	0
10K/sec. (10,240)	400	15 sec.
20K/sec. (20,480)	800	1 min.
40K	FAO	2 min.

Both random number generators can be reset manually. They are automatically reset at the beginning of each run when in the automatic scan control mode.

Automatic Update

A block diagram of the automatic update function is shown in Figure C-9. Other parts of the system are shown as they are involved in the performance of this function.

Basically, this function allows the user to define a set of runs to be performed with one or more system parameters varied automatically from run to run. One set that is frequently used is shown on the block diagram.

The test would be setup as follows:

1. Test will consist of 6 runs
2. Duration of each "ON" scan interval = 150 scans
3. Duration of each "OFF" scan interval = 7 scans
4. Fruit rate is to be 0, 500, 1000, 2500, 5000, and 10,000/sec.

This test would then be performed automatically if the scan control mode and automatic update modes were enabled.

When the output video was gated off at the end of the first 150 scan interval, the automatic update logic would load a new stop address into the Function PROM stop latch.

The automatic update logic would then increment the function and auto update address counters and the new fruit rate of 500 per second would be loaded. If this is the only variable, the action would then terminate until the end of the next 150 scan "ON" interval. The cycle would then be repeated for 1000, 2500, etc., until the end of the sixth run. The video would then remain off, the "end of run" indicator will illuminate. At the beginning of each "ON" scan set, the automatic update logic also resets the random number generators so that the fruit pattern is the same for each 150 scan segment.

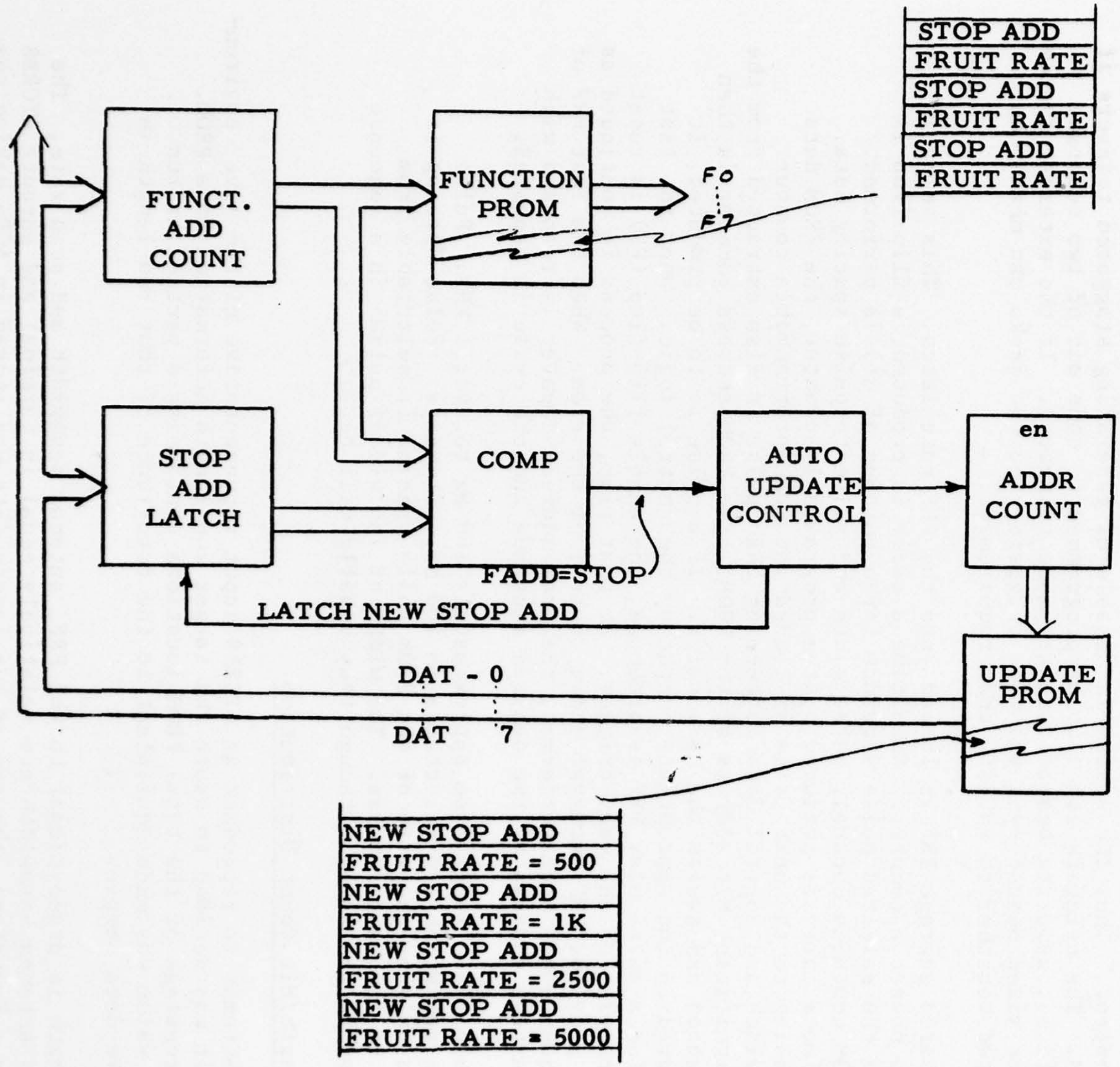


FIGURE C-9. AUTO UPDATE FUNCTION BLOCK DIAGRAM

Internal Trigger Generator

Figure C-10 is a block diagram of the internal trigger generator. It can produce a variable number of pulses with programmable widths and spacing for each pulse repetition frequency (PRF) interval under the control of an internal counter. The number of pulses per PRF, spacing, and width are under PROM control. Thus the system is capable of generating staggered triggers if desired. The triggers can also be programmed to come out of two separate ports (i.e., separate beacon sync and mode triggers). If the external system requires mixed beacon sync and mode triggers, the two jacks can merely be connected together to satisfy that requirement.

The desired average PRF is loaded into the PRF rate latch. This value is used to preset a counter. Each time a carry is produced, a flip-flop is set and the selected pulse sequence (or a portion of it) is performed. The PROM contains control, pulse width and pulse-to-pulse spacing data. Each time a carry is produced by the programmable counter, the PROM data for spacing to the next pulse is loaded into the programmable counter. Pulse width and control data concerning that pulse is also extracted from the most significant bit address of the PROM. The PROM address counter is then incremented and awaits the next carry. If a pulse is to be produced, it is steered to the appropriate output by the control logic. When the last pulse for a particular PRF is produced, the enable flip-flop (FF) is reset until receipt of the next trigger. At that time, the process is continued as in the previous PRF interval under control of the Prom. When the last PRF of a sequence has been performed, the Prom address counter is reloaded with the starting address of the desired sequence and the cycle is repeated.

Allowable PRF's range from approximately 160 Hz to over 1 MHz. Pulse spacing and width are selectable in 100 ns increments. Pulse spacing is limited only by the size of the PROM while spacing is selectable from 100 ns to 1.6 μs per pulse. The width of individual pulses in a sequence need not be the same, although they usually will be.

Run Length/Hit Count Distribution

In an attempt to reproduce an ATCRBS input representative of the live" environment, it was decided to store the target run length information in a PROM. The percentage of the total PROM locations containing a particular run length value was made equivalent to the occurrence of that run length in the live data sample.

Run length is proportional to the PRF, antenna beamwidth and scan rate. The PRF and antenna beamwidth are relatively equal in terminal and enroute ATCRBS systems. Therefore, the system run length data was stored in ACPs making the run length adjustment automatic when changing the scan rate (assuming the same PRF and beamwidth).

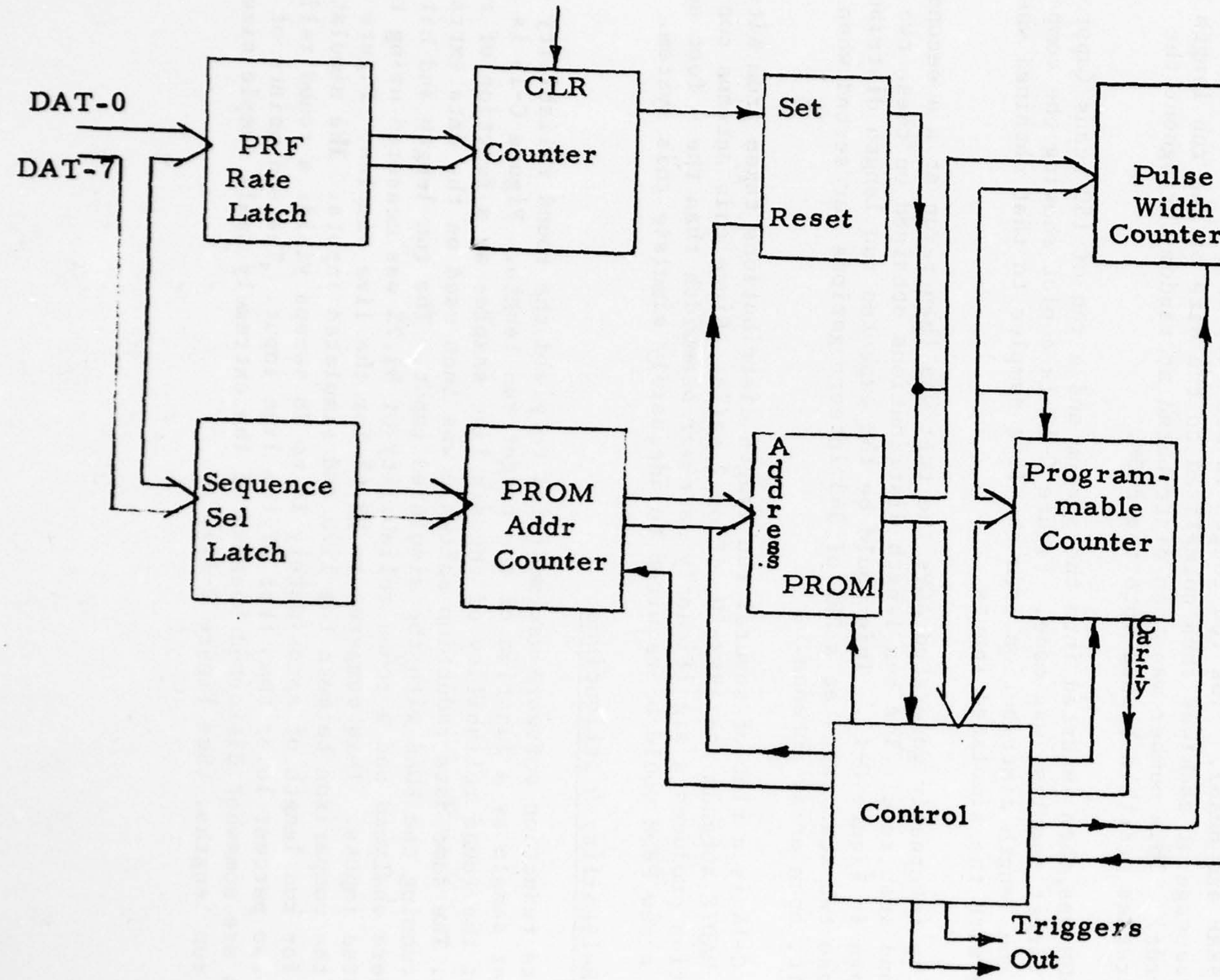


FIGURE C-10 - BLOCK DIAGRAM INTERNAL TRIG GENERATOR

The SRAP and BDAS programs were both modified to add the capability of extracting both hit count and run length data. Six samples of approximately 500 scans each were then extracted over a period of several weeks using both the SRAP and BDAS as inputs.

Figure C-11 is a plot of the run length distribution obtained from these six samples using the 4 foot open array antenna at 12.75 rpm and a PRF of 343 interrogations per second. Also indicated is the runlength distribution selected for use in the PROM. (The run length values were measured in sweeps by the SRAP and BDAS). The run length values were then converted to ACPs. The percentage of each was then normalized to the size of the run length PROM (512 words). This number was then distributed at random throughout the 512 addresses and then burned into the PROM.

This PROM was then inserted into the system and a run of 150 scans (approximately 10,000 target samples) was made. Figure C-12 is a plot showing the comparison of the run length distribution from the live samples to that obtained when running with the simulated inputs.

Using the internally generated ACPs the test was then rerun at a 4 second and 10 second scan rate. The run length distributions obtained on these two runs are shown in Figure C-13. This would be the expected run length distributions for these two scan rates at a PRF of 343 inteerrogations per second when using the 4 ft. open array antenna.

Figure C-14 is a plot of several run length distributions taken from sites with a NADIF antenna and ARSR-1D, 1E or 2 sails. Since this antenna configuration produces a significantly narrower beamwidth than the 4 foot open array, a new PROM would be required to adequately simulate this system.

<u>Round Reliability Distributions</u>

The data reduction software was modified to yield the round reliability of a target sample as a function of the target run length. Figure C-15 is a plot of the round reliability of the six live samples as a function of run length. The same data reduction software was then used on the data extracted while running the BDAS with the simulated input. The run length and hit count data were analyzed and a round reliability of 91.2% was measured using the simulated inputs. This compares to 92.6% for the live samples. Figure C-16 shows the comparison between the live and simulated inputs. The simulated input for run length of aproximately 14 to 28 sweeps yields a round reliability about two percent lower than that of the live input. The end points of both curves are somewhat distorted because of the extremely small sample size for those run lengths. (See Figure C-12).

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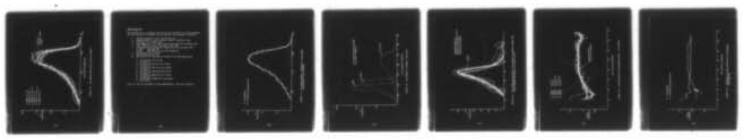

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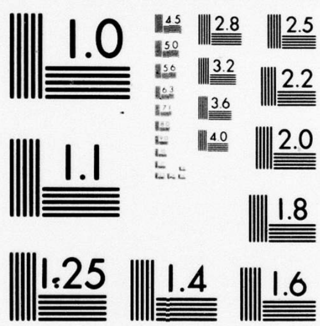

MICROCOPY RESOLUTION TEST CHART

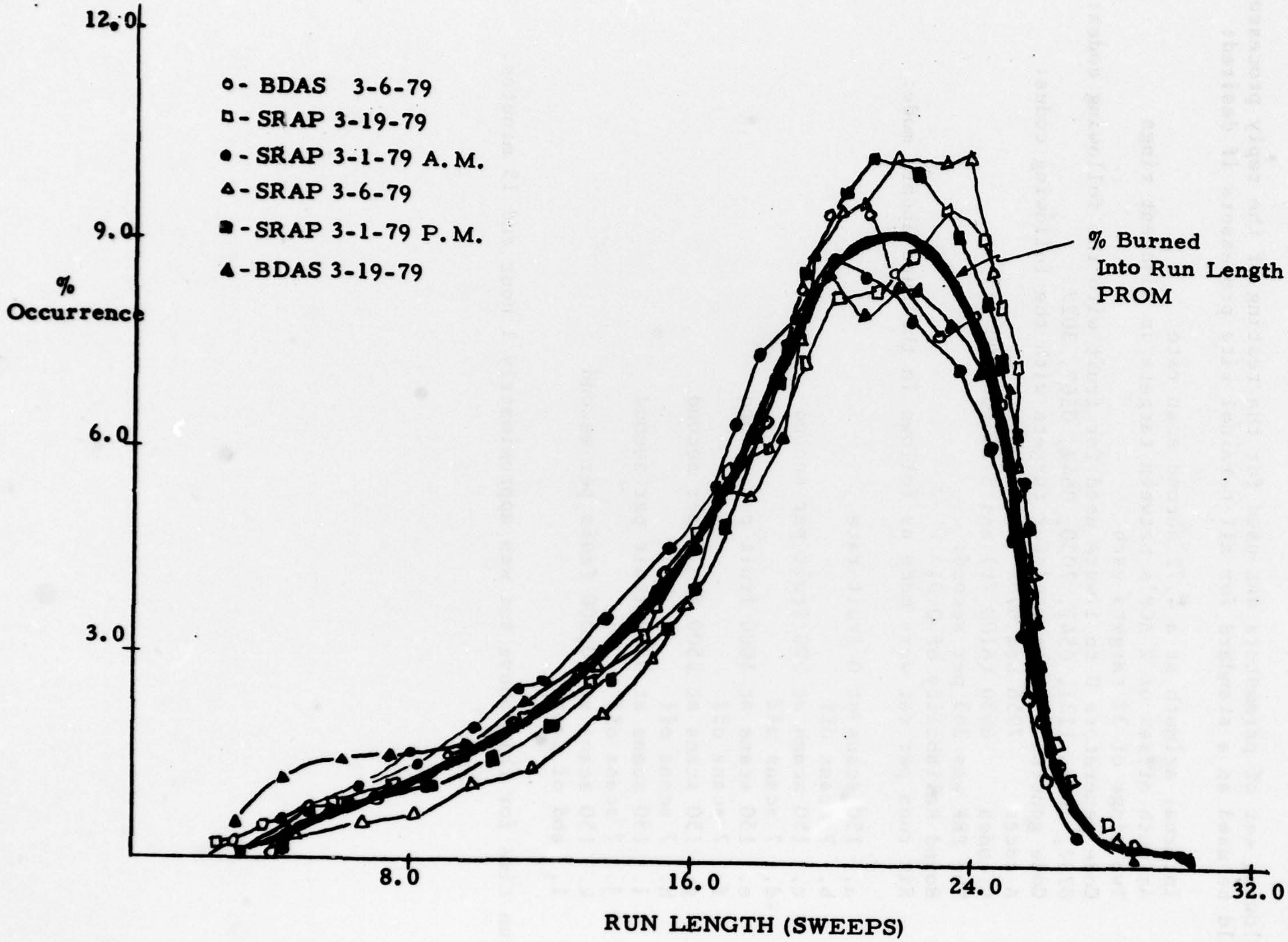

FIGURE C-11. RUN LENGTH PLOTS FROM LIVE DATA SAMPLES

Typical Data Set

The following set of parameters was used for the testing of the reply processors and could be used as a standard for all terminal site processors if desired:

1. Internal azimuth at a 4.72 second scan rate
2. Azimuth offset of 2 ACP's between targets in adjacent rings
3. Two rings of 32 targets each
4. Code generators 0 to 1 were used for fruit with the following codes: 0737, 7024, 1231, 0541, 7030, 0647, 0567, 3022
5. Code generator 2 was used for targets with the following codes:
   A codes 7056 and 6761
   C codes 6630 (8100 ft) and 5724 (36,000 ft)
6. The PRF was 343 per second.
7. Round Reliability of 0.91
8. Six runs per set were made as follows in the auto update mode:

   a. 150 scans at 0 fruit rate
   b. 7 scans off
   c. 150 scans at 500 fruit per second
   d. 7 scans off
   e. 150 scans at 1000 fruit per second
   f. 7 scans off
   g. 150 scans at 2500 fruit per second
   h. 7 scans off
   i. 150 scans at 5000 fruit per second
   j. 7 scans off
   k. 150 scans at 10,000 fruit per second
   l. end of test

Total run time for this above set was approximately 1 hour and 15 minutes.

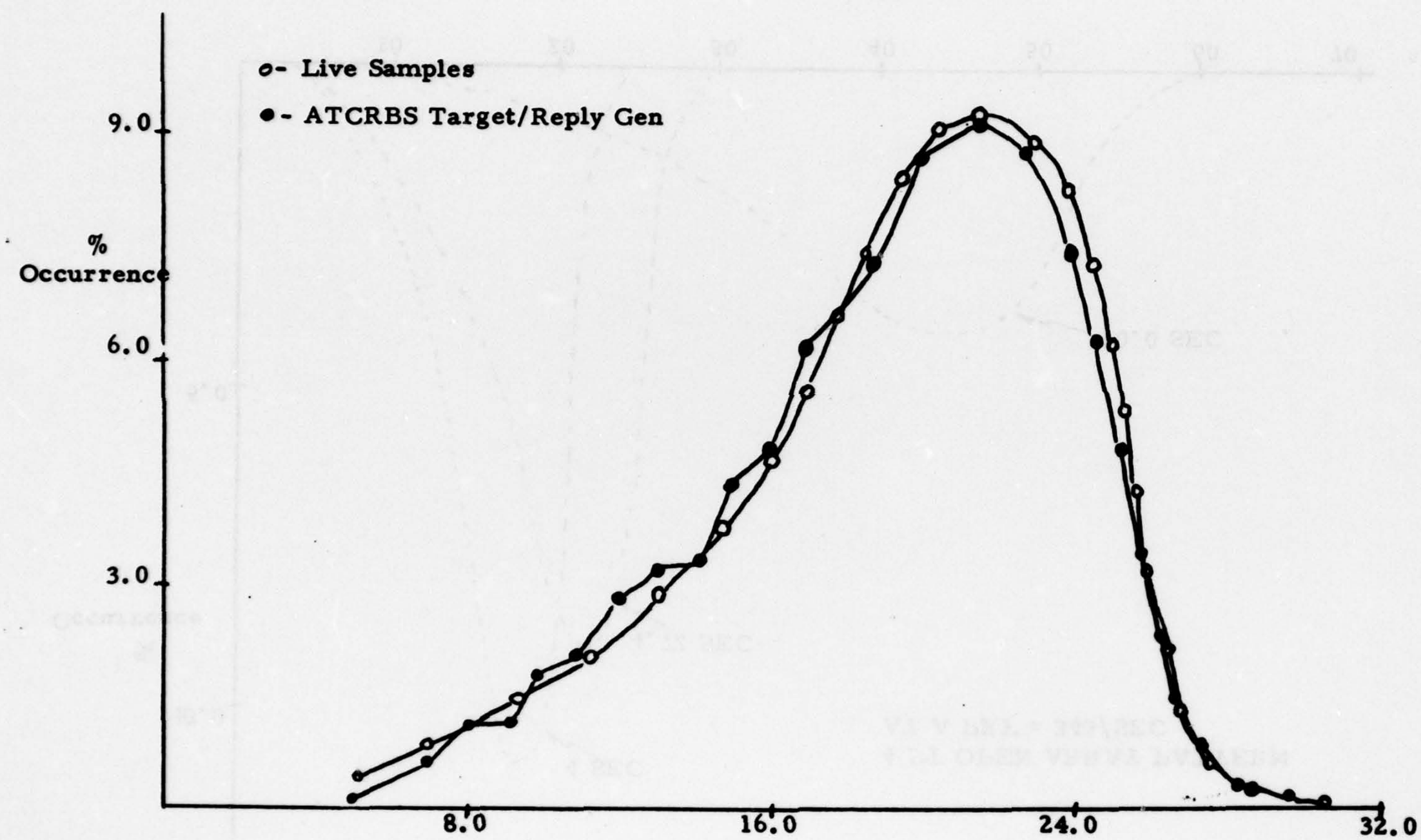

FIGURE C-12. RUN LENGTH SWEEPS - COMPARISON OF RUN LENGTH DISTRIBUTIONS LIVE/SIMULATED

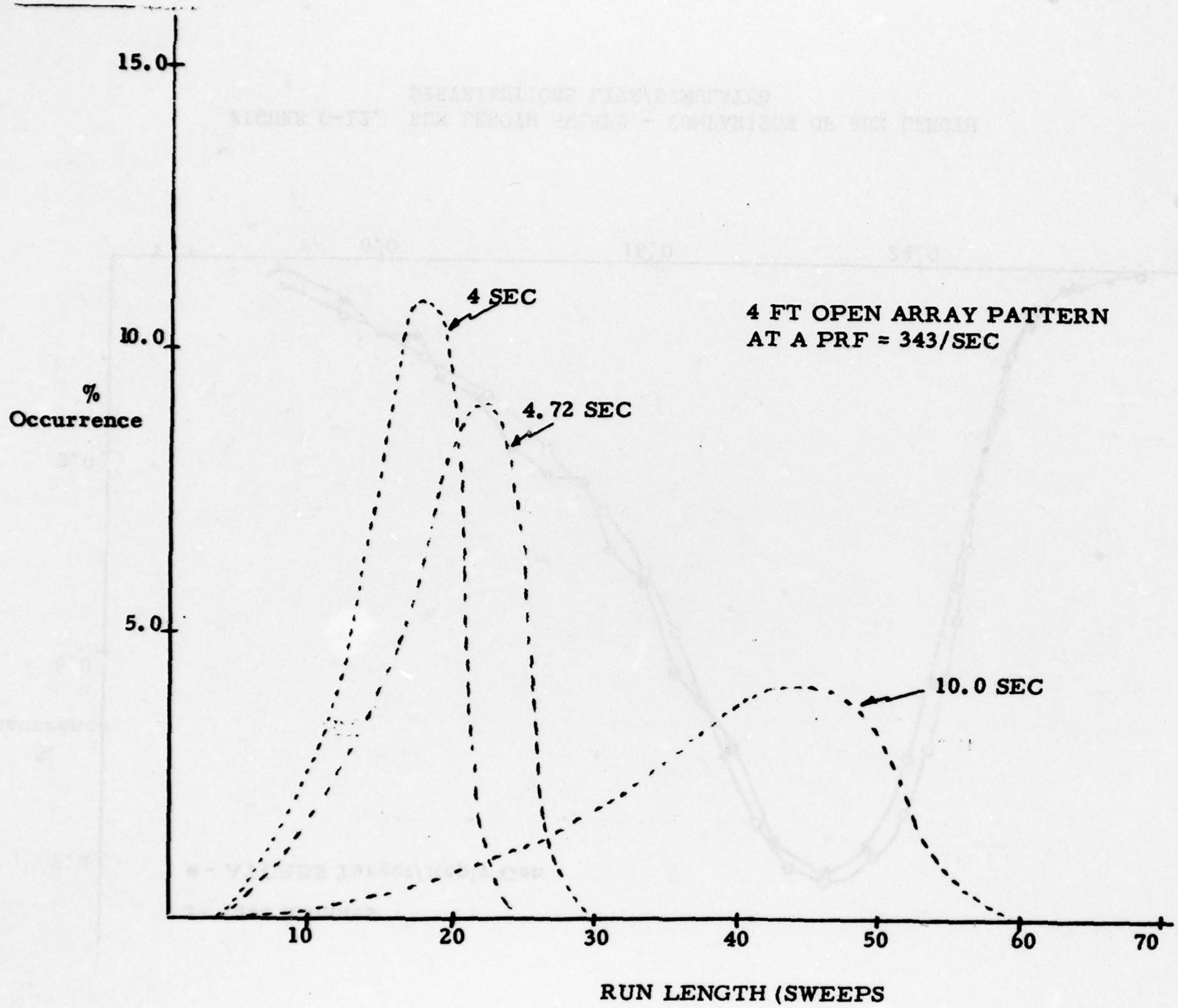

FIGURE C-13. RUN LENGTH AT DIFFERENT SCAN RATES

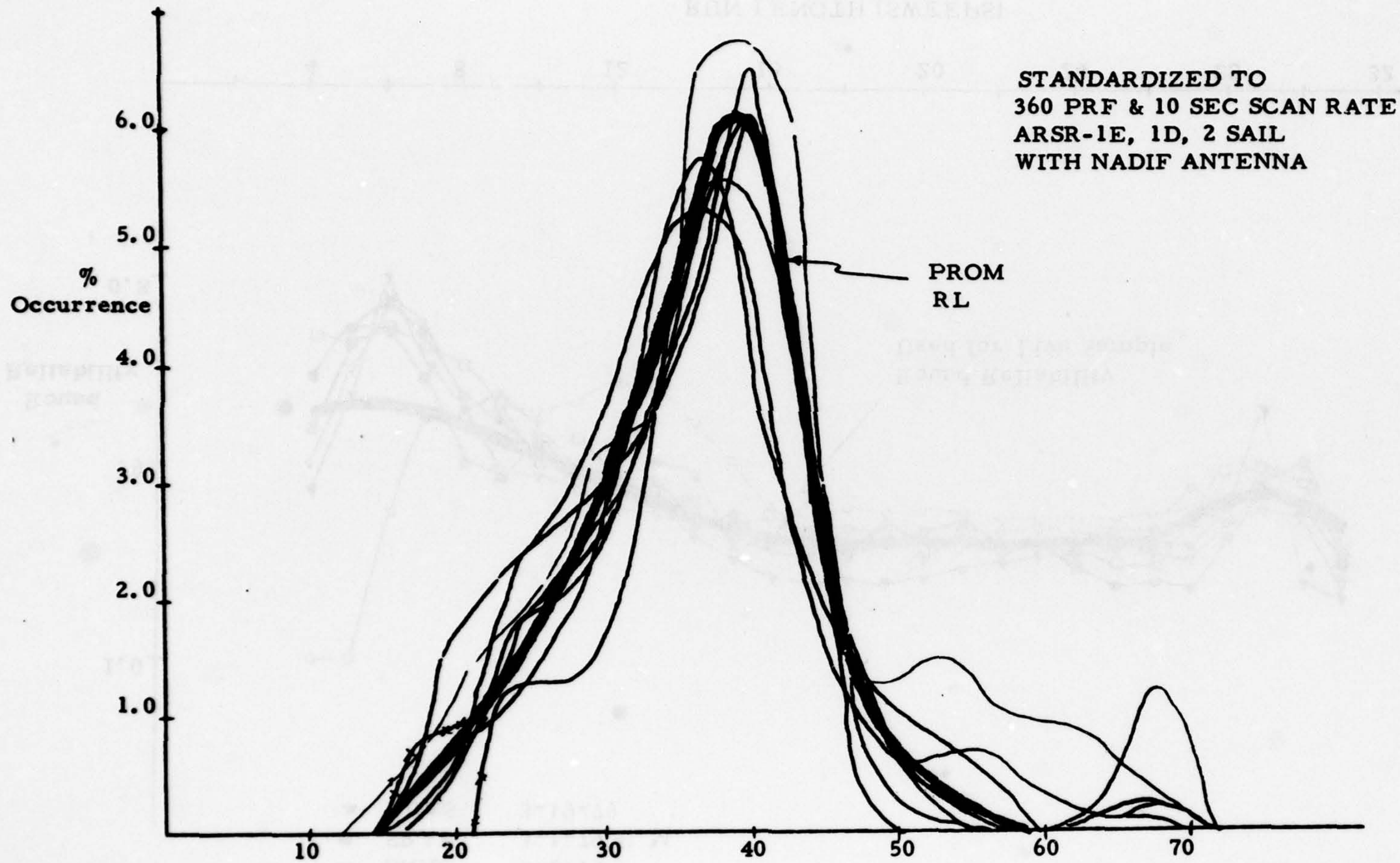

FIGURE C-14. RUN LENGTH DISTRIBUTION (LIVE SAMPLES) OF ENROUTE SYSTEMS WITH NADIF ANTENNA AND ARSR-1D, 1E, AND 2 SAILS

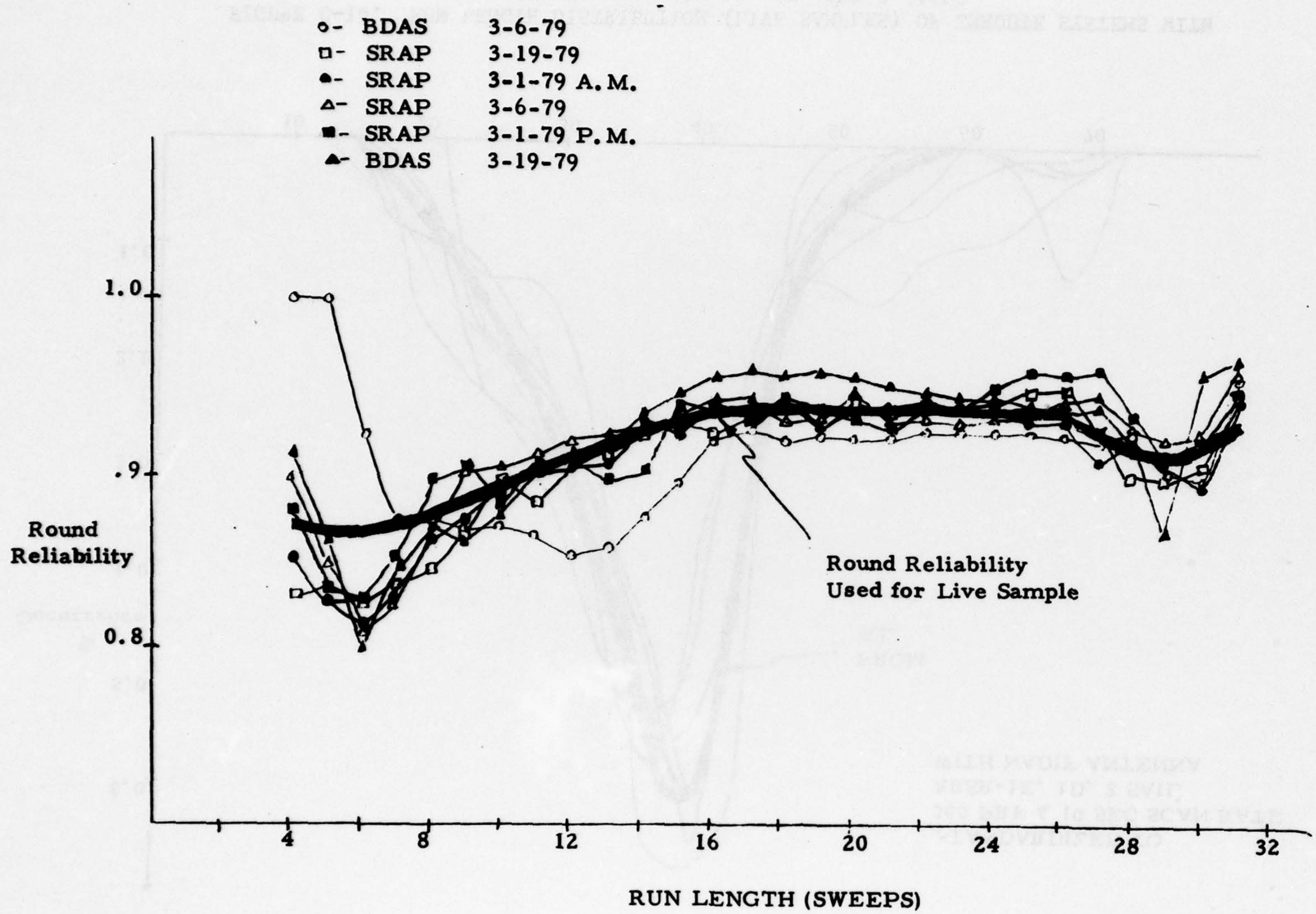

FIGURE C-15. ROUND RELIABILITY DISTRIBUTION PLOTS - LIVE SAMPLES

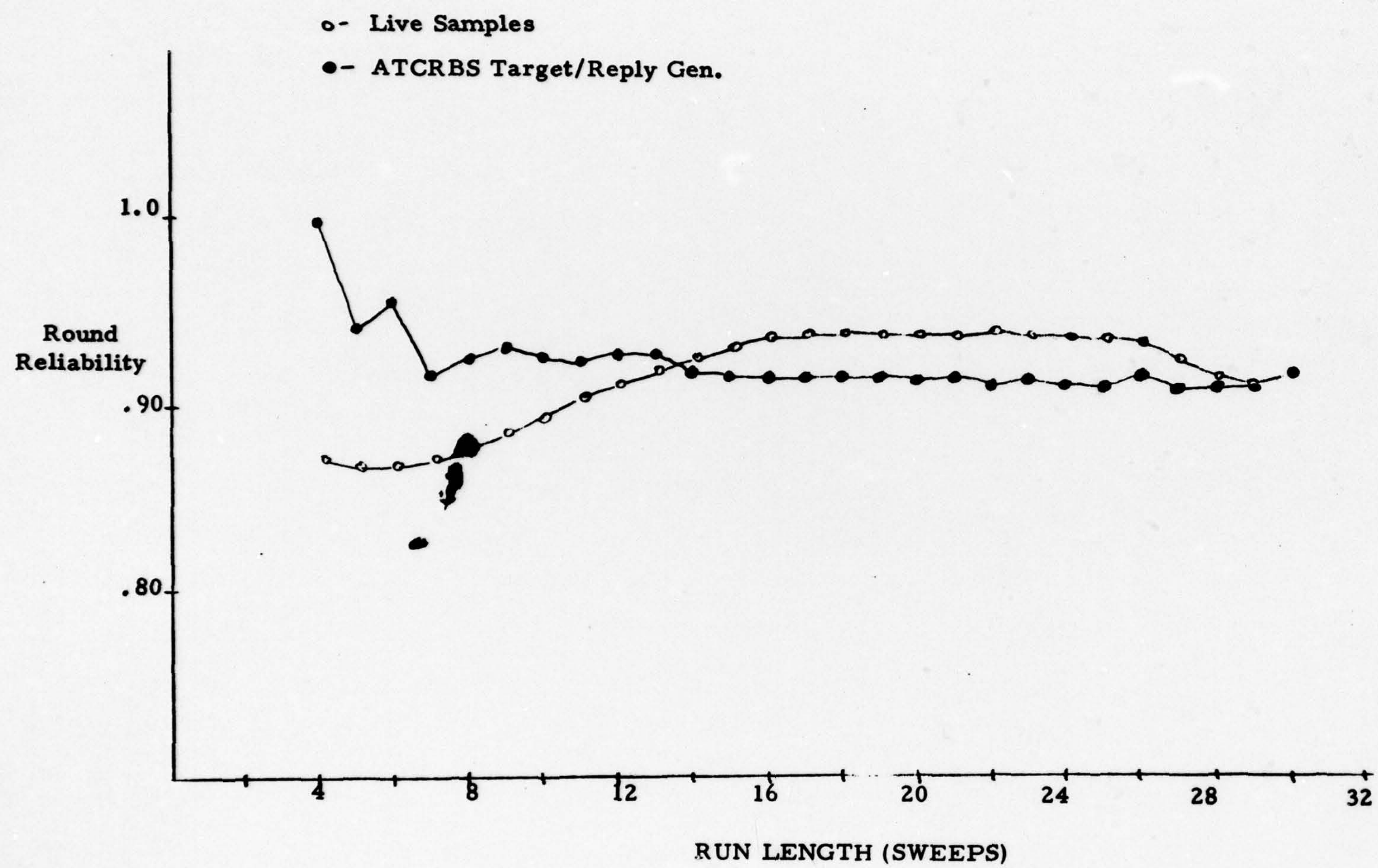

FIGURE C-16. COMPARISON OF ROUND RELIABILITY DISTRIBUTIONS LIVE/SIMULATED